Raptor Research

A Quarterly Publication of The Raptor Research Foundation, Inc.

Volume 20, Number 3/4, Fall/Winter 1986

(ISN 0000-0000)

Contents

The Raptor Research Foundation, Inc.
Provo, Utah

THE RAPTOR RESEARCH FOUNDATION, INC.
(FOUNDED 1966)

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Published quarterly by The Raptor Research Foundation, Inc. Business Office: Jim Fitzpatrick, Carpenter Nature Center, 12805 St. Croix Trail, Hastings, Minnesota 55033, U.S.A.

RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 20 FALL/WINTER 1986 No. 3/4

REPRODUCTIVE BIOLOGY OF NORTHERN HAWK-OWLS IN DENALI NATIONAL PARK, ALASKA

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ABSTRACT — Two nesting pairs of the Northern Hawk-Owk (*Surnia ulula*) were studied in 1980 in Denali National Park, Alaska. Observations began during the incubation phase and ended when the young left the nest and could no longer be found. During this period information was gathered on food habits and breeding biology. Owls did not return to breed in the study area until 1984 when a pair layed eggs at a nest used in 1980. Failure to breed, at least in 1981, was apparently the result of a substantial decrease in the microtine population.

Surprising little is known about the status and biology of the Northern Hawk-Owl *(Surnia ulula)*, particularly in North America. Walker (1974) claimed that hawk-owls have been reduced considerably in North America but offered no explanation to account for the reduction. Fyfe (1976) described it as rare to low in abundance in eastern Canada and low to moderate in abundance in central and western Canada. In Europe, Mikkola (1972) believed that hawk-owls had suffered a general population reduction in Finland, Norway, and Sweden, based on small recent invasions. Adequate raptor data are hard to obtain because of the generally low densities of raptors and their habit of nesting in remote and inaccessible places (Newton 1976). The fact that owls are secretive and nocturnal further compounds the problems of obtaining adequate data.

Bent (1938) summarized most early information available on the hawk-owl in North America, and Gabrielson and Lincoln (1959) summarized information on their breeding biology in Alaska. More recently Smith (1970) published information on various aspects of the reproductive habits of hawk-owls near Ottawa, Canada. Information on the hawk-owl in Europe is more extensive (Mikkola 1983).

Although no studies have provided detailed descriptions of hawk-owl breeding behavior, similarities in appearance and behavior between hawk-owls and the diurnal falconiforms are apparent. According to Sparks and Soper (1970), the hawk-owl is an ecological vicariate of a diurnal falcon or accipiter, and behaves like a falconid even though it is primarily a predator of small mammals. Harrison (1973) speculated that the hawk-owl may be filling a vacant diurnal niche.

Here I describe aspects of the breeding biology and behavior of Northern Hawk-Owls nesting in Alaska.

STUDY AREA AND METHODS

Two hawk-owl nests were studied; both were on the north slope of the Hines Creek drainage at about 670 m elevation in Denali National Park, Alaska. The 2 nests were west of park headquarters (R7W,T14S,S7 and R7W,T14S,S12) and 1.8 km apart. Both were within 100 m of the park road.

The nests were located in open needleleaf forest (Viereck et al. 1982) dominated by white spruce *(Picea glauca)*. Aspen *(Populus tremuloides)* and balsam poplar (*Populus balsamifera*) occurred uncommonly. Ground cover consisted largely of willow *(Salix* spp.) in wet areas and dwarf birch *(Betula nana* and *B. glandulosa)* in dry areas. Labrador tea (*Ledum palustre*), blueberry (*Vaccinium vitisidaea*), and crowberry (*Empetrum nigrum*) also occurred. Sphagnum was thick in places. Annual rainfall at Denali Park headquarters averages about 37.5 cm, with summer rains and occasional summer snow accounting for most of the total. Daylength varies from 12 hrs in late March and September to 22 hrs. in late June.

Field Observations - Hawk-owls were observed for 137 hrs between 12 May and 5 July 1980. A 20-45x zoom lens spotting scope and 9x binoculars were used to observe all activities. Owls appeared to habituate to observer presence allowing observations to be made from a distance of

less than 60 m from the nest. To reach nests, trees were climbed directly or with the aid of an aluminum ladder. Additional observations of hawk-owls were made in 1977 and 1984. In 1977, a nest from which 5 young fledged was visited twice between 11 June and 2 July, and a different group of 5 fledglings was located on 27 June. In 1984, a pair of adults was observed between 24 March and 7 April near a nest used in 1980. Data from 1976 were from the park observation files.

Clutch sizes in 1980 were measured by climbing to the nest, while brood sizes were determined from the fact that all known eggs hatched and young fledged. In 1976 and 1977 the number of young fledged served as an index of both the minimum clutch sizes and brood sizes.

I noted plumage differences that enabled me to recognize sexes of adults at both nests following observations of copulation, prey exchange, and egg-laying. Males had grayish-brown or blackish-brown barring while in females barring was a lighter chestnut-brown. In the male, the border between the upper breast and foreneck was demarcated by a contrasting blackish band, while the transition in the female was less distinct. The differences were more apparent in one pair than in the other and, according to Mikkola (1983), these kinds of differences can be attributable to age.

Food Habits. Information on food habits was obtained from the analysis of 387 pellets, by direct observation of prey brought to young, and from discarded prey remains. Analysis of pellets provided over 95% of cricetid, 100% of soricid, and about 10% of sciurid and avian prey data. All remaining data was obtained by observation of prey delivery and the location of discarded remains. Pellets were collected beginning on 16 May and it was assumed that all pellets were cast during the 1980 breeding season. Microtines were identified to species on the basis of dentition (Bee and Hall 1956; Hall and Kelson 1959), and a collection of dentition was sent to the University of Alaska for verification. When dentition was lacking or badly fragmented, prey remains were placed in higher taxonomic categories.

Most pellets were collected at scattered and often previously unsearched locations. Since the date when they were cast could not be determined accurately, trends in food habits were determined by direct observations of prey brought to young and by discarded prey remains.

Numerical abundance of prey from pellets was determined by counting pairs of small mammal jaws and by examining skeletons of larger mammals and birds. The biomass contribution of each species was calculated by multiplying numbers of individuals found by mean prey wt. Average prey wts were determined from specimens in the University of Alaska Museum (Appendix 1).

RESULTS AND DISCUSSION

Food Habits. A total of 651 prey remains was recovered from the 2 nests, including at least 4 species of birds and at least 8 species of mammals (Table 1). Mammalian prey comprised over 94% of the combined total biomass, with birds contributing the remainder. Diets of both pairs of owls were similar qualitatively, but differed quantitatively, especially in relative use of *Clethrionomys rutilus*. Pellets from the 2 nests averaged 1.53 and 1.72 prey items, respectively, for an overall average of 1.61 prey items/pellet (range 1 to 4) at both nests. Mikkola (1972) found an average of 1.7 prey items/pellet in Finland.

Microtine voles, particularly *C. rutilus* and *Microtus* sp., were the most important prey of hawk-owls, contributing at least 70% of the total prey biomass. Mikkola (1972) found that voles, particularly *Clethrionomys* sp. and *Microtus* sp. were extremely important in the diet of hawk-owls in Finland, Norway, and Russia, contributing 94.8, 98.3, and 97.7% respectively, of the total prey items. *Clethrionomys* sp. was numerically most important in all countries except Finland, where *Microtus* sp. was most prevalent. Although infrequently represented in European studies, the Water Vole (*Arvicola terrestris*) comprised 99.4% of the prey taken by 2 pairs of hawk-owls nesting on Ulkokrunni Island, Finland in 1977 (Pulliainen 1978). Thus, use of microtines by hawk-owls in this study is comparable to other areas.

The Varying Hare *(Lepus americanus)* and Red Squirrel *(Tamiasciurus hudsonicus)* comprised over 20% of the total prey biomass, a surprisingly large percentage considering that the biomass contributions of sciurids and leporids have not been quantified previously, although hawk-owls are known to prey on them. Dixon (1938) claimed that the Great Horned Owl *(Bubo virginianus)* and hawk-owls were important predators of Varying Hares in Denali National Park. Henderson (1919) observed hawk-owls carrying remains of Varying Hare, but concluded that they probably had been scavenged.

On 27 May the wing of an adult Willow Ptarmigan *(Lagopus lagopus)* was found near a pile of hawk-owl pellets. Flesh remaining on the wing was extremely dessicated, indicating that the ptarmigan had not been captured recently. Ptarmigan, and other grouse, apparently are not important prey items during the breeding season (Table 1), although they are reportedly taken during winter (Fisher 1893). Birds, especially *L. lagopus*, were taken 30 times more frequently during winter than summer in Finland (Mikkola 1972). During the time hawk-owls are confined to the vicinity of their nests, the Gray Jay *(Perisoreus canadensis)* is probably

Table 1. Relative frequency of occurrence and relative biomass of prey in the diet of 2 pairs of Northern Hawk-Owls in Denali National Park, Alaska. Total number of prey items=651; total prey biomass=20.641 kg.

SPECIES	% NUMBERS	% BIOMAS
Bird		
Tetraonidae		
Lagopus lagopus	0.15	2.60
L. lagopus or *Canachites canadensis*	0.31	0.39
Corvidae		
Perisoreus canadensis	0.92	2.09
Fringilidae		
Spizella arborea	0.31	0.07
Zonotrichia leucophrys	0.15	0.12
Small bird	0.92	0.64
Mammal		
Soricidae		
Sorex cinereus	1.39	0.18
Sorex hoyi	0.15	0.01
Leporidae		
Lepus americanus	0.92	9.43
Sciuridae		
Tamiasciurus hudsonicus	2.15	10.85
Cricetidae		
Clethrionomys rutilus	49.00	35.54
Microtus miurus	5.84	4.97
M. miurus or *Microtus pennsylvanicus*	5.53	4.71
Microtus oeconomus	19.82	18.13
Microtus sp.	5.22	4.45
Lemmus sibiricus	0.46	0.49
unidentified microtine	6.76	5.33
Total	**100.00**	**100.00**

a more important source of food than grouse (Table 1).

Trends in Predation. Hawk-owls exploited hares, squirrels, and birds in late May and continued to do so until observations ended on 5 July. Predation on these larger animals was related to the availability of large numbers of easily captured young.

Predation by hawk-owls on Varying Hares was restricted entirely to juvenile hares, taken between 31 May and 24 June. O'Farrell (1965) estimated that first litters of hares were born in late May and that the breeding season ended in late July near Fairbanks, Alaska.

Red Squirrels were taken by hawk-owls between 17 May and 2 July. Although owls preyed predominantly on juvenile squirrels, they also took adults. Since Red Squirrel populations do not fluctuate as widely as those of hares, Red Squirrels probably represent a more uniform food source from year to year than do hares.

Juvenile Gray Jays were taken by hawk-owls between 25 May and 19 June. Young Gray Jays are generally available as early as 15 April; thus they may have been taken more frequently prior to the beginning of observations. Most migrant birds arrived in late May or early June, and fledglings of migrant species generally appeared during the 2nd wk of July. Other than the nestlings and occasional adults of a few migrant, ground-nesting species,

Figure 1. Portion of the bog where male hawk-owl from nest A frequently hunted in 1980.

such as the American Tree Sparrow *(Spizella arborea)* and White-crowned Sparrow *(Zonotrichia leucophrys)*, owls did not regularly prey on migrant birds.

Hunting Habitat. Hawk-owls in Denali National Park frequently hunted in open areas with scattered trees. The male at nest A, for example, hunted a white spruce bog where 60% of 25 observed hunting strikes took place (Fig. 1). The bog, located at 0.60 km NW of the nest, was in an area of widely spaced, stunted white spruce < 4 m tall. The sparse open understory was composed of willow, labrador tea, and blueberry. Poor drainage promoted the growth of a thick sphagnum ground layer. The open understory and sphagnum substrate apparently enabled the male owl to hunt easily. The male at nest B was observed also to hunt an area with short white spruce and a ground cover of scattered shrubs and thick sphagnum.

Foraging Behavior. Hawk-owls captured prey by pouncing from an elevated perch (Table 2). Elevated perches were always spruce trees, and 92% (N=25) of the perches were at the top of a tree. When scanning for prey, owls leaned forward so that the body and tail were nearly horizontal, and the head was tilted downward, presenting a very kestrel-like silhouette. When prey was located the owl's head "snapped" into a fixed position and the body became rigid. When making a strike, owls launched into a gliding dive. If the strike distance was great (Table 2), owls flapped their wings a few times before beginning their descent. Roughtly 2/3 of the hunting strikes of male hawk-owls were successful (Table 2). When potential prey was not properly situated, hawk-owls leaned far forward while engaged in exaggerated tail pumping, a kestrel-like behavior. In extreme cases owls opened their wings and appeared as if to pounce, almost falling off the perch before regaining their balance. At other times owls glided to a lower perch and waited. On 3 July, for example, a male was perched atop a 6 m spruce when he apparently located prey below and immediately flew 3 m and perched at the top of a 2 m spruce. After 20 sec, he glided to a perch 0.60 m high and pounced onto a vole. Hovering by hawk-owls has been noted (C. Collins pers. obs.; Mikkola 1983), but was not observed in this study.

The young of ground-nesting birds were captured on the ground. On 22 June a male owl dropped from its perch atop a 5 m spruce and took a tree sparrow nestling from the nest. Twenty min later the male owl returned, descended to the same nest, and took the remaining nestling. I did not observe the manner in which owls captured fledglings or adult birds.

Hawk-owls may take arboreal prey in a different way. On 15 June, a perched male turned to face a tree about 7 m away and launched into a rapid glide directly toward a young Red Squirrel climbing the trunk. The owl flew directly toward the trunk, and hit a branch, but the squirrel moved out of range before contact was made.

Feeding Behavior. Hawk-owls generally "prepared" prey before feeding. Microtines were eviscerated prior to, or sometimes after, removal of the head. Prey items were eviscerated by a tear in the side, which opened the peritoneal cavity just anterior to the hindlegs. Owls pulled out and discarded the intestines and the stomach. The re-

Table 2: Hunting success, perch height, and strike distance of hawk-owls in Denali National Park, Alaska.

	NO. OF OBSERVATIONS	MEAN SUCCESS (%)	MEAN (M)	RANGE	S.D.
Hunting success					
male	28	68			
female[a]	5	20			
total	33	61			
Perch height (male)	25		5.41	0.61—10.61	2.61
Strike distance (male)	18		8.10	0.91—21.21	5.47

[a]80% of the female's strikes occurred while her tail feathers were molting.

mainder of the organs were eaten, and a few times the intestines were swallowed as they were pulled from the rodent. Large prey items were not eviscerated, at least not immediately, but the organs may have been discarded or consumed at a later time. Varying Hares, Red Squirrels, and Gray Jays often were partially plucked before they were eaten.

Except for very small prey, such as fledgling sparrows and young microtines, which were swallowed entire, hawk-owls always began feeding by removing and eating the head, including the relatively large heads of Red Squirrels. In the case of microtines, after the head was removed the remainder was usually swallowed intact. Prey larger than *Microtus* sp. were dismembered more completely and eaten in several pieces. Adult owls did not always completely consume large prey. At various perch sites I found the discarded tails and hindlegs of Red Squirrels, and the legs of Gray Jays. Owlets were observed swallowing the legs and tails of squirrels on occasion.

Food Caching. Hawk-owls cached excess food 47 times during observations. Food was cached more frequently after owlets left the nest than when they were in the nest. During incubation and brooding, when the female remained at the nest, the male conducted all caching and food retrieval. When brooding of the young was completed the female also cached and retrieved prey. The male was twice observed caching prey in a favorite hunting area about 0.60 km from the nest. Prey almost always was cached at least 3 m above the ground on spruce boughs or spruce brooms (caused by the rust *Chrysomyxa arctostaphylii*).

All sizes of prey were cached. Some large prey items were fed upon periodically for up to 24 hrs. Three rodents were retrieved and consumed 5 hr, 1 hr, and 15 min, respectively, after being cached.

Smith (1922) first observed food caching by a hawk-owl during the breeding season, and Collins (1976) and Ritchie (1978) described the food caching behavior of captive and wild hawk-owls, respectively.

Nest Trees. In addition to the 2 nests studied in 1980, single nests were found in 1977 and 1982. All nests were located inside the hollow tops of white spruce trunks 2 to 10 m above the ground (Table 3). In Europe, nests were usually 4 to 5 m above the ground (range 2 to 13) (Glutz von Blotzheim and Bauer 1980). All nest trees were dead, and in all cases nest cavities probably formed when the tops of diseased trees blew off, exposing the hollow upper trunk (Fig. 2). The nest cavities were characterized by sections of old trunk projecting 0.3 to 0.9 m above the nest. Owls entered the nest cavity over low points in this shell. Eggs were laid directly on decomposed sapwood.

Nesting Chronology. In 1980, owls were seen near nest A on 17 April by park employees. On 18 April, a rodent was passed from one adult to another at a habitually used perch. In 1984, when nest B was first reoccupied, owls called near the nest tree on 24 March. On 27 March, one adult was perched at the nest cavity entrance and a microtine was exchanged nearby. According to Eckert (1974), hawk-owls begin breeding (presumably selecting nest sites) in mid-March, and sometimes as early as February. Henderson (1919) observed a pair "in

Table 3. Dimensions of 4 hawk-owl nests in Denali National Park, Alaska.

MEASUREMENT	NEST A (1980)	NEST B (1980)	NEST FOUND IN 1977	NEST FOUND IN 1982	MEAN	S.D.
Height of nest above ground (m)	7.82	9.91	5.08	2.51	6.33	3.22
Cavity depth (cm)	2.6	15.4	14.1	12.8	11.2	5.8
Cavity diameter (cm)	19.2 x 23.1	14.4 x 17.3	21.8 x 25.6	—	18.5 x 22.0	3.8 x 4.3
Tree diameter at breast height (cm)	47.7	40.0	47.3	35.9	42.7	5.8
Tree diameter at nest height (cm)	29.8	20.4	35.1	23.7	27.3	6.5
Tree height (m)	8.74	10.21	5.56	3.18	6.92	3.16

Figure 2. Hawk-owl nest tree (nest B) discovered in 1980.

the act of breeding" on 19 February in Alberta, Canada. Mikkola (1972) found that they began calling as early as 17 February in Finland, and after the beginning of March in Russia, with territories being established a "few weeks" before nesting began. The initiation of breeding apparently can begin as late as early May (Harrison 1973).

Assuming an incubation period of 28 d (Harrison 1973; Terres 1980), and back-dating from the date of egg-hatching, the mean date of clutch initiation in 1980 was calculated to be about 19 April (range 13 to 24 April). Elsewhere in Alaska nests containing eggs range from 16 April to 18 May (Gabrielson and Lincoln 1959). In Alberta and central to southern Canada, eggs normally were found between 30 March and 5 June, and in Labrador and Newfoundland between 9 May and 11 June (Eckert 1974). Extreme dates when eggs were found in Lapland and Finland range from 30 March to 23 June.

The mean date of hatching in 1980 was 17 May (11 May to 22 May). This estimate was based on the condition of the young at nest A. On 29 May the nest contained 4 downy, white young, all with their eyes closed. Spotted Owls and Short-eared Owls open their eyes at 8 to 9 and 7 to 8 d after hatching (Clark 1975; Forsman 1981). Assuming that hawk-owls open their eyes at about 7 to 9 d, and considering the different sizes of the young at the time the nest was examined, I estimated the oldest young to be about 1 wk old when I first examined the brood in late May.

Hawk-owls left the nest in early and mid-June (1 to 5 June and 11 to 15 June). If calculations of hatching dates were correct, the young left the nest when approximately 20 to 22 d old (Fig. 3).

Roles of Adults During Incubation. Incubation was performed entirely by the female, while the male did all the foraging. Mikkola (1972) also found that females did all incubation. The female at nest A remained on the nest except for short periods when she left to receive food, preen, cast, or defecate. When not foraging the male perched in the tops of nearby trees about 30 m from the nest.

Food was usually exchanged away from the nest. Generally the female did not respond immediately when the male arrived with food and he either cached the food or, more commonly, flew to the nest and perched at the cavity entrance. The male frequently flew to the nest entrance several times before the female left the nest and accepted food at a nearby perch.

Roles of Adults During the Nestling Period. The female at nest A brooded the young almost constantly for the first 10 d to 2 wks after eggs hatched. During this time, foraging was conducted entirely by the male. Until the young were about 2 wks old the female received all food at the nest. After the 2nd wk the female left the nest to receive food at nearby perches. Toward the end of the nestling period the female spent almost all of her time perched outside the nest. At this time the male visited the nest only to deliver prey and, when not foraging, usually perched at least 100 m from the female.

Roles of Adults During the Post-Nestling Period. During the first 10 d after the young left the nest females perched nearby constantly. When not foraging, males continued to perch about 100 m from females.

Ten to 11 d after leaving the nest, owlets moved

Figure 3. Owlets approximately 17 days after leaving the nest, 37 days old on 28 June.

further from nest trees, flying up to 30 m horizontally and frequently landing on the ground. When they landed on the ground near a potential perch, they usually would climb. At this time males began to perch nearer the young and even brought food directly to them on occasion. Males were observed to offer only small intact prey to the young, while females often fed owlets pieces of prey.

The female at nest A was first seen hunting about 2 wks after owlets left the nest and by 27 June, 3 days later, roles of the sexes had changed drastically. The female was now absent for periods of at least 5 h and, although presumably hunting part of the time, seldom brought food to the owlets. The male fed and guarded the young in the absence of the female, and owlets were left alone for varying lengths of time when the male foraged. On 5 July, the last day of observation, the male at nest A continued to perch near the young and provided almost all their food. The female at nest B was not observed hunting.

Clutch and Brood Size. Clutch and brood sizes of nests in this study (Table 4) were similar to those reported elsewhere. According to Bent (1938), hawk-owls lay between 3 to 9 eggs, usually 7. Mikkola (1972) recorded a mean clutch size of 6.31 (range 3 to 13), and a mode of 5 for 135 completed clutches in Europe.

Nest Success. Both nesting attempts in 1980 were successful, with no infertile eggs or nestling mortality. Hawk-owls also nested successfully in 1976 and 1977. Virtually no quantitative information is available on nest success or reasons for nest failure in hawk-owls.

Tail Molt. Mayr and Mayr (1954), and Collins (1961) summarized information on tail molt of several species of small owls, although tail molt of the hawk-owl has not been well described. Wheelwright (1863:8443) stated that "the old birds may be seen in deep moult, without tails, even before the young are flyers."

Only the female at nest A molted her tail during the nesting period. The pair at nest B dispersed before tail molt was initiated by either adult. Tail feathers of the female at nest A were first noticed

Table 4. Productivity of hawk-owls in Denali National Park, Alaska.

YEAR	NESTING ATTEMPTS	CLUTCH SIZES	BROOD SIZES	∓ FLEDGLINGS / SUCCESSFUL NEST
1976[a]	2	5,6	5,6	5.5 (2)
1977[a]	2	5,5	5,5	5.0 (2)
1980	2	4,5	4,5	4.5 (2)

[a]nesting attempts, clutch sizes, and brood sizes in 1976 and 1977 are represented by minimum numbers, based on family groups located.

missing on 24 June, and only the 2 central tail feathers remained on 26 June, indicating that the molt was centripetal; the innermost rectrices were last to molt. On 29 June all her rectrices were missing. By 12 July her new tail feathers appeared to be about 20.0 mm long, or about 12% of their total length (Eckert 1974).

Among smaller owls (those with wing lengths < 210 mm) the tail molt is simultaneous, while among larger owls (those with wing lengths of > 230 mm) it is usually gradual or irregular (Mayr and Mayr 1954). Wing lengths of male and female hawk-owls average 220.9 mm and 226.0 mm, respectively (Earhart and Johnson 1970). Simultaneous tail molt in the hawk-owl, then, would extend the upper limit of wing lengths of owls predicted by Mayr and Mayr to undergo simultaneous molt. Since the tail feathers of small owls usually are shed over a period of several days to several weeks, Forsman (1981) has suggested that the word "simultaneous" be used sparingly.

Nest Defense and Natural Enemies. Of the interspecific encounters witnessed, a male hawk-owl defended its nest most vigorously against a Northern Goshawk *(Accipiter gentilis)*. On 20 May the owl attempted to intercept a goshawk that was flying directly toward the nest tree. The goshawk was 200 m away, and flying rapidly about 35 m above the ground when the owl left its perch and flew toward it. The hawk-owl flew past the goshawk without striking it, and then banked and pursued the goshawk until the accipiter was about 40 m beyond the nest.

Other than the goshawk encounter, hawk-owls remained perched when other raptors flew into view. The Golden Eagle *(Aquila chrysaetos)*, for example, soared high over the nest at least once every 2 observation days, but hawk-owls only watched until the eagle disappeared from view. Other raptors elicited a more vigorous response. On 21 May, a perched male hawk-owl stiffened as a Red-tailed Hawk *(Buteo jamaicensis harlani)* sailed rapidly over the nest. Although it remained perched, the owl called several times and was visibly agitated.

I observed no instances of hawk-owls being pursued by other raptors and no instances of predation on adults or young were recorded. Hawk-owls, however, often were harassed by other birds, particularly the Gray Jay, American Robin *(Turdus migratorius)*, and Varied Thrush *(Ixoreus naevius)*. Robins and Varied Thrushes attacked hawk-owls vigorously, diving from above and in 3 to 4 instances struck perched owls. These attacks disrupted the activities of hunting owls, and on several occasions males flew to the nest area with Robins or Varied Thrushes in pursuit. A male hawk-owl once responded aggressively when it was attacked by an American Kestrel *(Falco sparverius)*. During the descent phase of each of the kestrel's 10 pendulum attacks, the owl jumped from its perch into the air and presented its talons to the falcon.

Cryptic Posture. On 2 different occasions, once in response to the approach of a goshawk and once in the presence of a low-soaring Golden Eagle, male hawk-owls assumed vertically elongated postures. The owl stiffened and the feathers of the breast, belly, and back were drawn tightly to the body. The wings also were pulled tightly against the body and the leading edge was aligned vertically. The feathers in the facial disc above the eyes were raised, making the eyes appear very large.

The posture was identical to the "concealing pose" of the Northern Saw-whet Owl *(Aegolius acadicus)* and the Boreal Owl *(Aegolius funereus)* as described by Catling (1972), and apparently is the same posture assumed by several other small strigids, including the Eastern Screech Owl *(Otus asio)*, Long-eared Owl *(Asio otus)*, and Elf Owl *(Micrathene whitneyi)* (Bent 1938; Ligon 1968).

1981 Breeding Season. Hawk-owls were seen occasionally in 1981, and did not nest in the study area. Other researchers have noted similar declines in hawk-owl numbers and reproductive success in interior Alaska (Dixon 1938; Murie 1963). Even though hawk-owls were not observed to breed in 1981, there were 14 sightings of single owls between 24 March and 15 September. Twice owls were observed < 2 km, and once only 0.3 km from 1980 nest sites.

Although hawk-owls feed on birds, squirrels, and young hares, they apparently depend on microtines for successful nesting, thus resembling other strigid rodent specialists which also respond to low rodent densities by failing to breed. Among 10 species of Fenno-Scandian owls, hawk owls were second only to Snowy Owls *(Nyctea scandiaca)* in the proportion of Microtinae in the diet (Mikkola 1983).

Hawk-owls did not breed again in the study area until 1984 when a pair layed eggs at a nest used in 1980. It was not determined if the owls bred successfully.

ACKNOWLEDGEMENTS

Permission to do research in Denali National Park was granted by John Dalle-Molle. During the field work I was aided by several park employees, especially Karen Laing, Rick McIntyre, and Rick Sladick. Weights of prey species were provided by Daniel D. Gibson and Stephen O. Macdonald of the University of Alaska Museum. Stephen O. MacDonald also provided valuable assistance in the identification of shrews and microtines. James R. Koplin, Humboldt State University provided guidance and freely imparted his knowledge of raptor biology throughout the study.

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Received: 16 December 1985; Accepted: 25 June 1986.

Appendix 1. Weights of prey species used to compute biomass consumption by hawk-owls.

SPECIES	NO. OF SPECIMENS	MEAN WEIGHT (G)	SOURCE
Birds			
Lagopus lagopus	60	550	UA[a]
L. lagopus or *Canachites canadensis*	—	40	estimated mean juvenile wt.
Perisoreus canadensis	33	72	UA[a]
Spizella arborea	—	7	estimated mean juvenile wt.
Zonotrichia leucophrys	26	25	UA[a]
Small birds	—	22	estimated mean juvenile wt.
Mammals			
Sorex cinereus	25	4	UA[a]
Sorex hoyi	25	3	UA[a]
Lepus americanus	24	325	mean juvenile wt., UA[a]
Tamiasciurus hudsonicus	29	160[b]	mean wt., UA[a]
Clethrionomys rutilus	25	23	UA[a]
Microtus miurus	25	27	UA[a]
M. miurus or *Microtus pennsylvanicus*	20	27	UA[a]
Microtus oeconomus	25	29	UA[a]
Microtus sp.	—	27	estimated
Lemmus sibiricus	25	34	UA[a]
Unidentified microtine	—	25	estimated

[a]Specimens in University of Alaska Museum
[b]Mean weight from a combination of adult and juvenile weights

Third World Conference on Birds of Prey, 1987. An International Conference will be held 22-27 March 1987 at Eilat, Israel. The Conference will be organized by the World Working Group on Birds of Prey in conjunction with the Israel Raptor Information Center and the U.S. Hawk Mountain Sanctuary Association. The Conference will consist of seven paper sessions, each of which may occupy up to one whole day. The themes and organizers are as follows: 1) Conservation and biology of rare raptors—U.-Meyburg and N. Collar; 2) Conservation and biology of rare owls—R. J. Clark and H. Mikkola; 3) Raptors on migration and wintering grounds—M. Fuller and J. M. Thollay; 4) Population biology and breeding—I. Newton; 5) Raptors in polluted environments—R. Risebrough and J. Ledger; 6) Education—Y. Leshem and J. Brett; 7) Legislation—P. Robinson. Contributions to these different themes can also take the form of poster papers.

The Conference will take place within the framework of an international festival, which will include a raptor photography competition (under the patronage of Eric Hosking), a painting and drawing competition (patron, Roger Tory Peterson), a film festival and competition, and ornithological and cultural excursions and tours.

During this season, the famous and massive migration movement of raptors over Eilat is in full swing, and in 1985 included 1.1 million raptors of 30 species. **For further information, write to the Honorable Secretary of the World Working Group, Mr. R. D. Chancellor, 15 Bolton Gardens, London SW5 0AL, UNITED KINGDOM.**

ROOST-TREE CHARACTERISTICS AND ABUNDANCE OF WINTERING VULTURES AT A COMMUNAL ROOST IN SOUTH CENTRAL PENNSYLVANIA

Anthony L. Wright, Richard H. Yahner and Gerald L. Storm

Abstract — Roost-tree characteristics and abundance of the Black Vulture (*Coragyps atratus*) and the Turkey Vulture (*Cathartes aura*) were studied during 2 winters at a communal roost in southcentral Pennsylvania. Vultures selected large conifers for roosting, which were easily accessible and probably offered a nocturnal microenvironment favorable for energy conservation. Turkey Vultures left the roost earlier in the morning than Black Vultures. Numbers of vultures were highest during mid-winter, and Turkey Vultures outnumbered Black Vultures during both winters. Recommendations are to preserve forest stands containing conifers in the vicinity of the roost and minimize human disturbances near roosts.

Although roosts and perching areas used by vultures have been described (Coles 1938; Davis 1974; Stewart 1978; Rabenold 1983), quantitative descriptions of habitat used by vultures during winter in the northeastern United States are lacking. We examined winter roost trees and abundance of the Black Vulture (*Coragyps atratus*) and the Turkey Vulture (*Cathartes aura*) at a large communal winter roost at the Gettysburg National Military Park, Adams Co., Pennsylvania. Our objectives were to determine (1) characteristics of roost trees used by vultures at the Big Round Top (BRT) roost, and (2) within- and between-year changes in abundance of both species at the roost during 2 winters.

Study Area and Methods

The study was conducted from 7 December 1982 to 5 March 1983 and from 27 December 1983 to 7 March 1984 at the BRT roost, which was used nightly by vultures during both winters (Wright 1984). The Harpers Hill and the Gettysburg Quarry roosts, used infrequently by vultures, were located within 5 km of the BRT roost (Wright 1984).

The BRT roost is in the Gettysburg Basin, which is a wide, level plain, except for low ridges (Socolow 1962). The city of Gettysburg (population 7,200) lies 3 km from the roost. Forests cover 32% of Adams County and are composed of 6% conifer (*Pinus* spp., *Picea* spp.), 81% oak (*Quercus* spp.), and 13% northern hardwood (*Betula* spp., *Acer* spp., *Fagus grandiflora*) forest types (Considine and Powell 1980). Mean temperature from December to February at Gettysburg is 0°C. Annual snowfall averages 73.7 cm, and precipitation from December to February averages 22.7 cm (Ruffiner 1980).

Description of the Roost. — Trees with at least 25% of the ground beneath the crown whitewashed by vulture excreta were defined as roost trees. All roost trees were white pine (*Pinus strobus*) located at the base of BRT. Control trees were those receiving little or no night use by vultures, as indicated by fewer than 2 large splashes of excreta beneath the tree. Control trees were chosen by following a 2-m wide transect in a random direction from each roost tree until an overstory white pine was encountered.

Fifteen variables (Table 1) were compared between roost trees and control trees with either single-classification analyses of variance or median tests (Daniel 1978; Sokal and Rohlf 1981). Stepwise logistic regression (BMDPLR, Dixon 1981) was used to predict use of a tree for roosting based on variables measured at each tree. The logistic model used was $E(s/N) = \exp(U)/(1 + \exp(U))$, where U is the linear combination of one or more independent variables, s is the sum of the binary (0, 1) dependent variable, and N is the total sample size. The maximum likelihood method of estimating variables with default options for remove limit ($P > 0.15$) and enter limit ($P < 0.10$) was used to build the model.

Counts at the Roosts. — Counts of vultures at the BRT roost were conducted 2 to 6 d/wk on mornings without measurable precipitation (< 0.25 mm), beginning 35 min before sunrise and continuing until 100 min after sunrise. A cutoff of 100 min was chosen arbitrarily as birds that did not leave by this time typically remained in the roost for most of the day. When possible vultures flying out of the roost were counted and identified to species from a vantage point that was 280 m from the main roost.

A correction factor (2.2 ± 0.8) was determined to account for birds that did not leave the roost during a given count. This factor, based on 5 counts during 1982-83, was the mean ratio of birds flushed to those visible in the roost before flushing. The number of vultures visible (both species combined) in the roost at the end of a count was multiplied by the correction factor to estimate the number remaining in the roost. When large numbers (≥ 60) of vultures were visible in the roost at the termination of a count, the count was considered unsuccessful; unsuccessful counts (N = 16/68) were discarded from analyses. The total number of vultures in a roost/count was equal to the number of birds leaving plus the estimated number remaining in the roost ($\bar{x}$ = 24 birds/successful count). Winter counts were divided into 3 winter periods: early winter, mid-winter and late winter (see Table 3).

Results

Comparison of Roost Trees with Control Trees. . . Vultures roosted only in white pines at BRT, although hardwoods made up to 58% of the overstory within the roost and 92% of the overstory within 0.5 km of the roost. Six variables related to tree size and amount of evergreen foliage were significantly great ($P < 0.05$) for roost trees than for control trees, whereas distance to the nearest roost tree was less for roost trees than for control

Table 1. Variables measured at roost trees of Black and Turkey Vultures and at control trees at Big Round Top roost, Adams Co., Pennsylvania (from Wright 1984).

VARIABLE	DESCRIPTION
Diameter at breast height	Diameter (cm) of tree measured at breast height (1.5 m) with tree diameter tape.
Height of tree	Height (m) of tree measured with Abney level and tape.
Height to lowest limb	Height (m) from ground level to lowest living limb greater than 6 cm in diameter at base, measured with Abney level and tape.
Maximum crown diameter	Maximum horizontal distance (m) between the ends of living limbs of trees measured by ocular tube with plumb-bob and tape.
Mid-tree crown diameter	Horizontal distance (m) between the ends of living limbs measured midway between ground level and tree top. Method of measurement same as crown diameter.
Distance to nearest roost tree	Distance (m) from roost or control tree to nearest roost tree measured with a 50-m tape or taken from a 1:1,600 aerial photo.
Distance to nearest clearing	Distance (m) from roost or control tree to nearest area of over 200 m essentially free of overhead vegetation. Measured by same method as distance to nearest roost tree.
Number of overstory trees	Number of overstory trees in a 0.04-ha circular plot.
Understory stem density	Density (100's of stems/ha) of shoulder height non-overstory, woody stems in 2 perpendicular 22.8-m transects in a 0.04-ha circular plot.
Percent evergreen canopy cover	Evergreen canopy coverage (%) based on 56 ocular tube readings evenly spaced on lines running in 8 main compass directions from center tree of a 0.04-ha circular plot.
Slope	Maximum ground slope (degrees) from tree to edge of a 0.04-ha circular plot, measured with Abney level.
Elevation	Elevation (m) taken from USGS 1:24,000 topographic map.
Canopy height	Mean height (m) of trees in a 0.04-ha circular plot. These are the center tree and the tree with the greatest diameter at breast height in each quarter.
Total basal area	Basal area (m) of all overstory trees in a 0.04-ha circular plot.
Basal area of white pine	Same as basal area, but only for white pine.

trees (Table 2). Basal area of white pine, understory stem density, and tree height were the best variables for predicting use of a tree for roosting: U = − 10.89 + 6.22 (basal area of white pine) − 0.01 (understory stem density) + 0.28 (height of tree). The model gave 81.2% correct classification of trees.

TABLE 2. Means $\bar{x}$ and standard deviation (SD) of 15 variables measured at roost trees of Black and Turkey Vultures and at control trees at Big Round Top roost, Adams Co., Pennsylvania, during winters 1982-83 and 1983-84.

	ROOST TREE (N = 33)		CONTROL TREE (N = 31)	
VARIABLE	$\bar{x}$	SD	$\bar{x}$	SD
Diameter at breast height[a]	57.42*	10.0	48.6	15.1
Height of tree[a]	28.8*	2.7	25.8	5.2
Height to lowest limb	17.1	2.5	15.4	4.0
Crown diameter	9.4	2.1	8.2	3.0
Perpendicular crown diameter[a]	7.5***	1.8	5.6	2.7
Distance to nearest roost tree[a]	7.9***	7.1	63.4	40.8
Distance to nearest clearing	109.7	27.7	130.7	89.4
Number of overstory trees	9.7	2.9	8.4	3.0
Understory stem density	97.8	75.1	114.6	111.7
Percent evergreen canopy cover[a]	38.3***	9.0	26.9	9.0
Slope	9.7	2.1	8.9	3.7
Elevation	167.1	0.3	164.7	0.9
Total basal area[a]	1.47***	0.35	1.16	0.36
Basal area of white pine[a]	0.90***	0.33	0.43	0.26

[a]Means or distribution of means varied between roost trees and control trees; *P ≡ 0.05, ***P ≡ 0.001, based on single-classification analyses of variance or median tests (Daniel 1978; Sokal and Rohlf 1981).

Counts at Big Round Top Roost. — The number of both vulture species combined was greater in winter 1982-83 compared to winter 1983-84 (Table 3). Mean number/count varied significantly among the 5 winter periods ($F = 45.3$; df = 4, 47; $P < 0.001$). Paired comparisons of means between winter periods were significantly different ($P < 0.03$), except for the comparison of late winter 1982-83 and late winter 1983-84 (Table 3). As a general trend, numbers increased in early winter, peaked and remained stable in mid-winter, and declined in late winter. Several large day-to-day changes in numbers at the roost also were documented (Wright 1984).

Turkey Vultures were more common than Black Vultures at the BRT roost based on all winter periods combined (Wilcoxon paired-rank test, $Z = -6.7$, $n = 63$, $P < 0.001$). The mean percentage of both Black and Turkey Vultures observed at the roost differed among periods ($F = 7.2$; df = 4.58; $P < 0.001$); pairwise comparisons of mean percentages of each species observed at the roost were significantly different between most periods (Table 4).

Table 3. Means, SD, and coefficients of variation (CV) for counts (N) of Black Vultures, Turkey Vultures, and vultures of unknown species combined at Big Round Top roost, Adams Co., Pennsylvania, during winter periods of 1982-83 and 1983-84.

PERIOD	DATES OF COUNTS	N	MEANS ± SD	CV
1982-83:				
Early winter	10 Dec 1982-27 Dec 1982	9	517 ± 239	46.1
Mid-winter	28 Dec 1982-16 Feb 1983	15	719 ± 85	11.8
Late winter	17 Feb 1983-5 Mar 1983	7	199 ± 82	41.4
1983-84:				
Early winter	------	a	a	a
Mid-winter	28 Dec 1983-6 Feb 1984	10	420 ± 74	17.8
Late winter	6 Feb 1984-6 Mar 1984	113125 ±	76 361.0	

[a]A total of 427 and 501 vultures was counted at the roost on 8 December and 17 December, respectively (E. Daniels, pers. comm.)

Numbers of individual birds departing the BRT roost/15-min time interval in the morning were dependent on species (G = 1,082; df = 8; < 0.001). Turkey Vultures tended to leave earlier than Black Vultures (Table 5).

DISCUSSION

BRT, Harpers Hill, and Gettysburg Quarry roosts are associated with ridges (Wright 1984), which presumably modify winds (Geiger 1965). Because both vulture species often use winds when soaring, ridges may have an effect on roost location by creating updrafts that were used as travel lanes (Wright 1984). Topography is known to affect the distribution of different species of African vultures according to their flight characteristics and body sizes (Houston 1975).

Vultures selected mature white pines rather than hardwoods as roost trees at BRT. Coles (1938) observed that vultures in Virginia abandoned a hardwood roost site and moved to a conifer roost site after leaf fall; a similar shift took place at BRT (J. Coleman, pers. comm.) Both white pines and hardwoods were used as roost trees at Harpers Hill;

Table 4. Mean ± SD of percent composition of Black and Turkey Vultures between winters and among winter periods at Big Round Top Roost, Adams Co., Pennsylvania, 1982-83 and 1983-84.

WINTER	WINTER 1982-83		WINTER 1983-84	
period	Black	Turkey	Black	Turkey
Early no data	20.5 ± 8.3[a]	79.5 ± 8.3	no data	no data
Mid-	29.4 ± 7.2	70.6 ± 7.2	40.2 ± 11.6	59.8 ± 11.6
Late	33.8 ± 16.0	66.2 ± 16.0	21.3 ± 13.4	78.7 ± 13.4
Combined	28.0 ± 10.5	72.0 ± 10.5	32.5 ± 15.4	67.5 ± 15.4

[a]All pairwise comparisons for each species were significantly different except between mid-winter 1982-83 and late winter 1982-83, and between all winter 1982-83 periods combined and all winter 1983-84 periods combined; Wilcoxon two-sample and Wilcoxon signed-rank tests (Sokal and Rohlf 1981).

Table 5. Percentages (numbers) of individual Black and Turkey Vultures departing from the Big Round Top roost, Adams Co., Pennsylvania, during 9, 15-min morning time intervals in winters 1982-83 and 1983-84 combined.

TIME INTERVAL (RELATIVE TO SUNRISE)	PERCENTAGES (NUMBERS) OF INDIVIDUAL BIRDS	
	BLACK VULTURES	TURKEY VULTURES
35 to 20 min before	0.4 (17)[a]	1.5 (167)
20 to 5 min before	9.1 (392)[a]	21.3 (2471)
5 min before to 10 min after	24.7 (1065)[a]	40.5 (5012)
10 to 25 min after	22.4 (965)[a]	12.7 (2203)
25 to 40 min after	15.2 (565)[a]	8.2 (1453)
40 to 55 min after	14.6 (628)[a]	8.1 (1417)
55 to 70 min after	9.4 (406)[a]	5.1 (903)
70 to 85 min after	3.5 (151)[a]	2.1 (360)
85 to 100 min after	0.7 (31)	0.5 (81)

[a]Numbers of departures per time interval varied between species; $P < 0.001$, based on 2 x 2 G-tests of independence, where rows are numbers of vultures/time interval of interest versus numbers/all other time intervals combined and columns are the 2 species (Sokal and Rohlf 1981).

3 Virginia pines (*Pinus virginiana*) were the major roost trees at Gettysburg Quarry where the forest type was > 95% hardwood (Wright 1984). Conifers reduce both wind velocity and nightly drops in ambient temperature during winter, suggesting that vultures lower daily energy requirements by roosting in clusters of large conifers (Francis 1976; Kelty and Lustick 1977. Stalmaster and Gessaman 1984; Walsberg 1986). Further strong temperature inversions form in mature forest stands on calm nights (Geiger 1965); therefore, a perch on an upper limb in a full conifer would afford a warm microenvironment to a roosting vulture. Finally, widely-spaced, horizontal limbs on dominant white pines enabled vultures to easily alight.

Numbers using the BRT roost may vary by year according to weather conditions. For example, mid-winter 1982-83 (January mean temperature, −0.1°C; monthly snowfall, 3.8 cm) was less rigorous than mid-winter 1983-84 (January mean temperature, −3.8°C; monthly snowfall, 18 cm). Numbers of vultures using the BRT roost were much lower in winter 1983-84, perhaps due to more vultures migrating farther south than in 1982-83.

The BRT roost presumably provides a favorable microclimate in mid-winter, but other factors (e.g.; information centers, Rabenold 1983, 1986; protection from predation, Weatherhead 1983; abundant winter food resources, Yahner et al. 1986), also may be important in explaining high use of this communal roost. Communal roosting by both species has been observed during summer months (Stewart 1978) and at southerly latitudes (Bent 1937; Coles 1938).

Although our results are based primarily on 1 roost in southcentral Pennsylvania, we recommend that forest stands containing conifers should be preserved near communal winter roosts. Efforts should be made to minimize human disturbances (e.g., road construction, forest clear-cutting) within a reasonable distance of a roost. In addition, large trees at pasture — woodland interfaces within 1 km of the roost were used readily by vultures at Gettysburg National Military Park (Wright 1984) and, thus, should be retained near roosts.

ACKNOWLEDGMENTS

Thanks are given to P. Rabenold, R. Shipmen, K. Steenhof, P. Stewart, J. Swenson and P. Weatherhead for reviewing an earlier draft of the manuscript; to H. Greenlee and J. Karish, National Park Service, for providing logistical support; to E. Daniels and J. Coleman for sharing information about vultures; to M. Fuller, U.S. Fish and Wildlife Service, for advice on field techniques; and J. Grimm for help with statistical analyses. This research was funded by the Pennsylvania Agricultural Experiment Station, the U.S. Fish and Wildlife Service, the National Park Service, and the

Max McGraw Wildlife Foundation. This is Scientific Journal Series Number 7149 of the Pennsylvania Agricultural Experiment Station, The Pennsylvania State University, University Park.

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Received 1 March 1986; Accepted 1 June 1986.

THE BARN OWL EGG: WEIGHT LOSS CHARACTERS, FRESH WEIGHT PREDICTION AND INCUBATION PERIOD

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Abstract. — A total of 177 Common Barn-Owl (*Tyto alba pratincola*) eggs produced by 14 captive pairs were studied during the spring of 1985, Initial egg parameters for 75 eggs were fresh weight (26.6 ± 1.4 g), length (43.07 ± 1.24 mm) and breadth (33.67 ± 0.70 mm). Using these data, a coefficient (K_W) unique to the barn owl egg was calculated for Hoyt's (1978) equation for predicting the fresh weight of an egg. (K_W = ° .0005453)

For 50 artificially incubated eggs (hatchability = 93.5%) the lay to pip (LP) interval was 28.2 ± 1.4 d, the pip to hatch (PH) interval was 2.1 ± 0.5 d and the overall incubation period was 30 ± 1.5 d. Variance in the latter period (range: 27-35 d) may have been due to an observed delay in initial embryonic development of from 1-7 d.

During incubation, several externally quantifiable changes occur in the avian egg. These include: 1) the relatively steady reduction in weight due mainly to loss of water vapor by diffusion from the embryonic chorioallantois through the porous shell and its evaporation at the eggshell surface (Romanoff and Romanoff 1949; Ar and Rahn 1980); and 2) the equal exchange of O_2 and CO_2 gases through the eggshell by the chorioallantois - a process not affecting weight loss (Wagensteen and Rahn 1970, 1971). The mean percentage of fresh egg weight (W_0) lost during the incubation period for many avian species ranges from 12-18% (Drent 1970). Proper weight loss is correlated with hatchability and normal embryonic development (Walsberg 1980). During artificial incubation, accurate regulation of egg weight reduction is possible through a variety of methods; (Burnham 1983; Weaver and Cade 1983).

A mathematical equation (1) based upon egg length (L) and breadth (B), parameters which are invariant during incubation, was developed by Hoyt (1978) to predict avian W_0.

$$W_0 = K_W L B^2 \quad (1)$$

The coefficient (K_W) of this equation interrelates shell measurements, and may be adjusted to accommodate a single species for accurate W_0 for Peregrine Falcon (*Falco peregrinus*) eggs, and also observed a reduction in W_0 of 15 ± 2% during incubation of normal eggs. However, our study of the incubation of common Barn-Owl (*Tyto alba practincola)* eggs indicates that they cannot be precisely characterized by values developed for Peregrine Falcon eggs. Our objective was to measure barn owl egg weight loss and incubation period, and algin Hoyt's equation for this species.

Materials and Methods

The barn owl breeding colony of the Raptor Rehabilitation and Propagation Project, Inc., Eureka, Missouri, was established in 1979 and produced more than 150 juvenile owls yearly through 1986 for release into Missouri. The colony contained non-sibling breeding pairs collected from eastern North America. Each pair was housed in an outdoor mew in a natural setting and was fed daily a diet of fresh rodents *ad libitum.* Human disturbance was normally limited to 2 short intervals.

Barn Owls will naturally produce >1 clutch of 6-8 eggs during favorable seasons (Eckert and Karalus 1974), and often breed repeatedly all year in captivity (Mendenhall, pers. comm.). Thus, 2 clutches/pair of owls were assured. The first clutch produced by each pair was removed for artificial incubation and subsequent clutches were left with the parents for natural incubation.

Beginning in early January, approximatley 2 wks before initiation of barn owl breeding, each mew was entered daily by 1 or 2 workers and the nest boxes were checked for eggs. This procedure was completed at a prescribed time every morning through April to ensure that no egg was older than 24 hr when initially measured, and to minimize non-random disturbance of the adult owls. As each freshly laid (+ 0-24 hr) egg was discovered, it was weighed on an electric field balance to determine W_0, and the dimensions were measured with a Vernier caliper. Additionally, each fresh egg was marked with a graphite letter corresponding to its sequence in the clutch. No egg was ever fully removed from the nest box and adults were kept at a distance during measurement. During the subsequent incubation period, each egg was weighed every other day using similar methods.

To reduce parental stress and promote successful copulation, no eggs were collected from nest boxes prior to clutch completion (W.C. Crawford, Jr. pers. comm.). Egg laying interval was approximately 1 egg every 2-3 d, thus eggs were from 1 to 16 d old when removed from the nest for artificial incubation. Eggs were incubated in Roll-X RX2A automatic rolling incubators with a constant temperature of 37.5° C, and relative humidity of 48%. Each egg was rolled manually 180° 3x/d to supplement automatic rolling. Throughout the lay-to-pip (LP) interval, each egg was weighed and candled every other day to determine both weight loss and corresponding embryonic development. Once an embryo had pipped its shell, the egg was placed pipped side upwards in another Roll-X RX2A set at a lower temperature (35°C) but higher relative humidity (60%). Pipped eggs were not turned. During the pip-to-hatch (PH) interval, no weight measurements were made due to shell fragility and difficulty in determining weight at the instant of hatching. Infertile eggs or eggs containing dead embryos were removed from the incubators to inhibit bacterial growth.

Eggs undergoing natural incubation were weighed similarly through pipping, but only occasionally candled to reduce nest disturbance. No extra care was provided for these clutches (i.e. cleaning of nest boxes, bad egg removal, etc.) unless a shell failed

Table 1. Mean total fraction of grams Wo lost over the 28 d lay to pip interval for Barn Owl eggs[a] incubated artifically and naturally.

INCUBATION	N[B]	$\bar{x}$	SD	MIN/MAX	CASES[C]	r[d]
Artificial	39	0.11	0.02	0.07-0.14	441	0.95
Natural	23	0.14	0.04	0.10-0.24	249	0.87

[a] Only fertile, successful hatching eggs represented.
[b] Number of eggs.
[c] Number of points used in generating r values and regression lines give Figure 1.
[d] Correlation coefficient relating cumulative fraction of Wo lost to day of incubation.

in a fertile egg; such eggs were removed for artificial incubation and excluded from the study. To prevent cannibalism, an occasional aspect of barn owl adult-chick behavior, the amount of food provided for each mew was increased considerably following the hatch of each egg (W.C. Crawford Jr., pers. comm.).

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) (Nie et. al. 1975). A regression line developed by the least squares fit was generated plotting the cumulative fraction of Wo lost by corresponding interval day. The resulting linear equation was used as a model (assuming 28 d LP interval) to predict the total fractional weight loss for all cases in each of the 2 incubation type categories. Other SPSS options were used to generate F-Test, t-Test, Pearson's r and Chi-squared (X^2) values and probabilities.

RESULTS

The mean total fraction of Wo lost during the LP interval was significantly different ($F = 07.05$ df = $P < 0.001$) between artificially and naturally incubated eggs which hatched successfully (Table 1). High degrees of correlation were found between cumulative reaction of Wo lost and interval day within each incubation group, implying that eggs dehydrated similarly in their respective categories although a wide range of total fraction of Wo lost by individuals was noted.

We defined hatchability as the percent of fertile eggs successfully hatched. The hatchability of naturally incubated eggs was 80.9% ($n = 62$). Hatchability between incubation types was significantly different ($\chi^2 = 4.56$; df = $P < 0.05$).

The relationship between day of incubation and cumulative fraction of Wo lost was examined (Fig. 1). An increase in the spread of points (statistically indicated by increasing standard deviations of residuals) from the regression line (Table 2), and corresponding decrease in correlation coefficients as incubation progressed through consecutive segments of LP interval were found. Both incubation types had this characteristic.

A species specific coefficient ($K_W = 0.0005453$) was determined using equation (1) for Wo prediction and the measured values of Wo, L and B collected from 75 barn owl eggs (Table 3). Using this K_W a strong correlation was found between directly

Table 2. Increasing deviation of points from regression lines indicated by increasing standard deviation of residuals and decreasing correlation between fresh Wo lost and incubation day.

INCUBATION	CASES[A]	r	P	RESIDUAL SD
Artificial				
0-10 days	136	0.83	≤ 0.001	0.7906
11-19 days	133	0.77	≤ 0.001	1.0272
20-30 days	172	0.67	≤ 0.001	1.2954
Natural				
0-10 days	101	0.75	≤ 0.001	1.3191
11-19 days	85	0.66	≤ 0.001	2.2498
20-30 days	56	0.29	≤ 0.01	3.9209

[a] Number of points used in generating the r values and regression lines given Fig. 1.

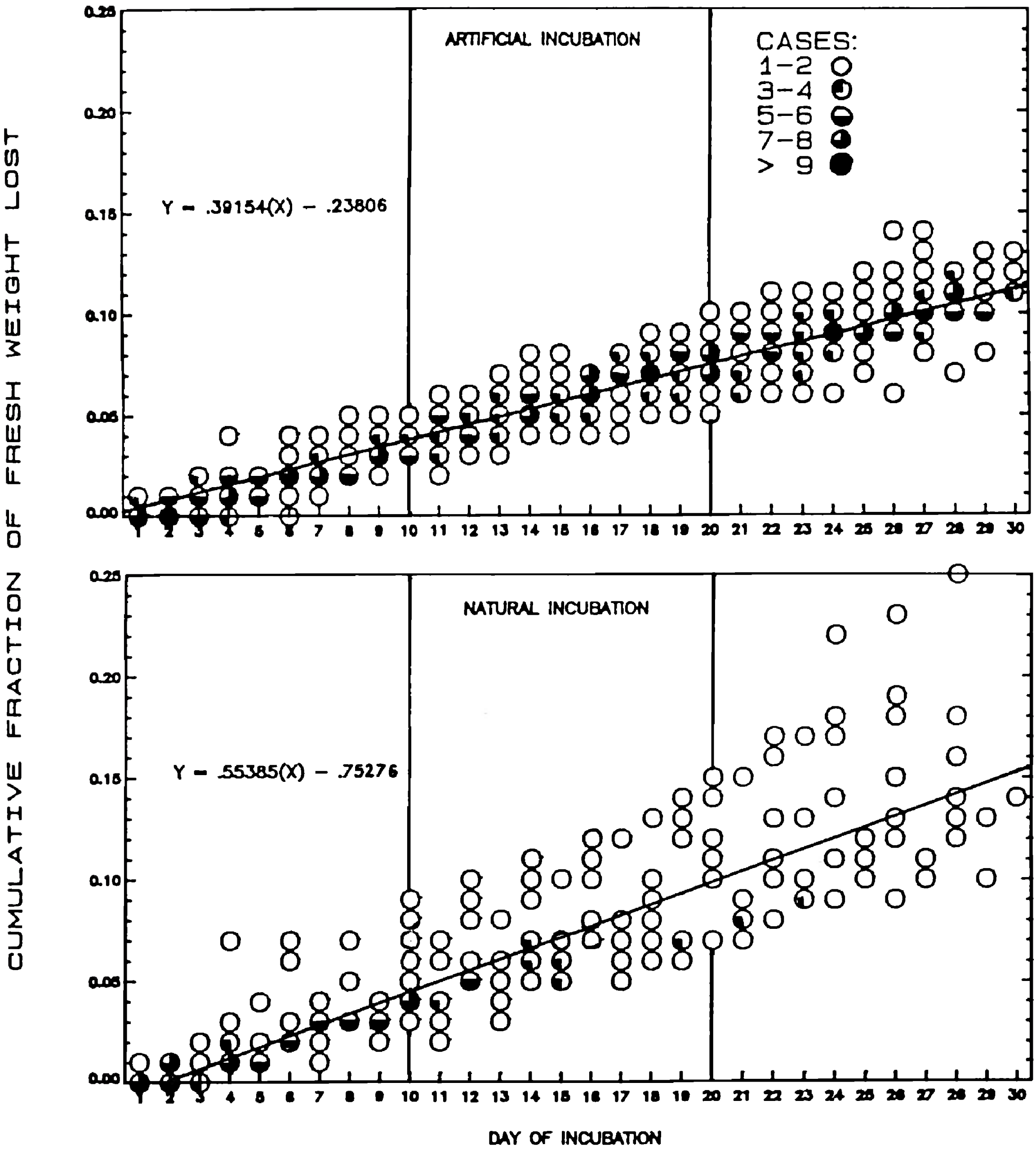

Figure 1. Regression of cumulative fresh weight lost in barn owl eggs by day of incubation.

Table 3. Summary of physical parameters from natural incubation and period of incubation for common Barn-Owl (*T.a.pratincola*) eggs incubated artifically.

PARAMETER	N	$\bar{x}$	SD	MIN/MAX
Length (l) (mm)	75	43.07	1.24	39.95-47.95
Breadth (B) (mm)	75	33.67	0.70	32.50-35.40
Fresh Weight (W_0) (g)	75	26.6	1.4	24.6 -29.9
Lay to Pip (LP) Interval (days)	50	28.2	1.4	25-33
Pip to Hatch (PH) Interval (Days)	50	2.1	0.5	1-4
Incubation Period (days)	50	30.3	1.5	27-35

measured and calculated values of W_0 ($r = 0.917$; $P < 0.001$); the 2 group means were similar (t-Test = 0.39; $P = 0.701$).

When the coefficient K_W ; 0.0005474 developed by Burnham (1983) was used in equation (1), strong correlation ($r = 0.917$; $P < 0.001$) was also evident between measured and calculated values of W_O, although statistical confidence in the similarity between the 2 group means was decreased (t-Test = 1.86; $P = 0.067$).

DISCUSSION

The total incubation period of the barn owl can be generalized from the literature as 30-33 d, with extremes of 29 and 34 d (Eckert and Karalus 1974; Bunn et. al. 1982). Our study indicatd a similar mean incubation period and range.

The mean W_0 value (Table 3) of the barn owl eggs studied is inconsistent with the mean (W_0) developed from the single random sample collected (from the wild) by Sumner (1929), and his values were reported in other works (Drent 1970; Ar and Rahn 1980). However, Hoyt (1978) noted that intraspecific variability in the values of W_0, *L and B could be expected and we have attempted to account for such deviation through relatively large samples collected from many pairs of owls within the subspecies T. a. pratincola.*

Careful, frequent illumination of eggs with cool, high intensity light provided good visual tracking of embryonic development. A small fraction of embryos did not achieve the visible blastodisc stage (indicative of fertility) for up to 7 d following the date of laying. However, most embryos apparently began their development immediately, and showed a blastodisc within 24 hr. A sharp increase in the rate of egg weight loss in conjunction with abrupt initialization of embryonic development in dormant-fertile eggs was routinely observed. After an extremely low rate of daily weight loss, these eggs suddenly achieved a relatively constant rate of weight loss which continued for about 28 d until a normal fraction of W_0 was lost. The chicks then pipped the eggshell. Thus, a specific weight loss rate occurred for the latter portion of the LP interval, although this interval may have been initially extended by the dormant-fertile condition. Since the PH interval was fairly constant, with variance probably due to observational error, nearly all deviation in the barn owl incubation period was due to the initial dormant-fertile egg. It was unclear whether the dormant-fertile condition was random or relative to other eggs' development within clutches, but eggs generally hatched in sequence of their laying. Quantification of this embryological characteristic was not possible using their sample and further study is required.

Although hatchability and mean total fraction of W_0 lost was related to incubation type (natural *vs* artificial), the 2 incubation methods are very differently affected. Factors inherent only during natural incubation include frequent variation in nest microclimate and ambient temperature and humidity, high bacterial exposure, and violent movement of delicate eggs by disturbed adult owls. Such relatively uncontrollable variables may have caused natural incubation weight loss rates to occur which do not parallel those of eggs in undisturbed

nests. These adverse factors undoubtedly contributed to the lower hatchability of fertile eggs undergoing natural incubation, although the sample analyzed includes many eggs from undisturbed nests.

Regression of weight lost by interval day reveals an increase in deviation between predicted and actual egg weights during the LP interval. Since weight loss is due to expired water vapor, as previously cited, this unexpected trend may reflect differential individual respiratory function, effected by the chorioallantois in conjunction with the eggshell, which was not subject to purely passive diffusion. This result contrasts with recent literature which cites simple diffusion down concentration gradients as the single force moving gases across the eggshell (Wangensteen and Rahn 1970, 19721).

Inferences drawn from these results are interesting to both the ecologist and the conservationist propagating this species artifically. *Tyto alba* supp. possess extremely favorable reproductive capabilities. Developmental flexibility is reflected in the variable egg weight losses achieveable during incubation and in the dormant-fertile condition which allows extension of incubation period. These factors may contribute to the high hatchability evident from the data in this study.

ACKNOWLEDGMENTS

We thank the Raptor Rehabilitation and Propagation Project, Inc., and W. C. Crawford, Jr., who has reintroduced over 500 barn owls in Missouri.

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Received 1 February 1986; Accepted 3 November 1986.

PREY AND TROPHIC ECOLOGY OF GREAT HORNED OWLS IN WESTERN SOUTH AMERICA: AN INDICATION OF LATITUDINAL TRENDS

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ABSTRACT — Quantitative information on the diet of three Great Horned Owl *(Bubo virginianus)* populations along 18 lat. degrees in western South America (Chile) is compared with that of Great Horned Owls in comparable latitudes along western North America. In Chile, owls preyed mainly on small mammals, with proportion of birds decreasing, and that of insects increasing, toward southern latitudes. Mean prey size and diet breadth declined toward southern Chile. These latitudinal trends closely mirror those documented in western North America.

Although the Great Horned Owl *(Bubo virginianus)* is distributed throughout the Americas, its food habits have received considerable study mainly in North America (Burton 1973). The only published quantitative information on their food habits in South America comes from central Chile (approximately latitude 33° to 38°; see Jaksić and Yáñez 1980; Jaksić and Marti 1984). Except for a preliminary report by Jaksić et al. (1978), no dietary information was previously available from their southernmost distribution (see Humphrey et al. 1970). Here we report the prey identified in 125 fresh pellets collected in September (austral spring) 1977 and in 14 other pellets collected in July (winter) 1978, from under the same nest located at Torres del Paine National Park (approximately 51° 01′S, 72°54′W; 142 km north of Puerto Natales). For purposes of comparison we report earlier dietary data published by Reise and Venegas (1974) in a Chilean journal of very local circulation. Their study material (an unreported number of fresh pellets, ± 55) was collected under one nest, located 10 km north of Puerto Ingeniero Ibáñez (46° 18′S; 71°55′W), in January (summer) 1971. For comparative purposes we also use Jaksić and Yáñez's (1980) report on the prey of the Great Horned Owl at La Dehesa (33°21′S, 70°32′W; 20 km east of Santiago), based on 98 fresh pellets collected during September (spring) 1979, beneath one nest. Although the information analyzed is based on very small sample sizes, we believe it is useful in consolidating new and old information fragmented in the Chilean literature and not readily available to ornithologists elsewhere.

METHODS

Considering that ca. 95% of the pellets analyzed reflect spring and summer diet, and that this dietary information covers approximately 18° latitude, a quantitative comparison seems warranted. We use the following trophic metrics: (a) Geometric mean prey weight in the diet — essentially the back-transformation of the mean prey size obtained with log-transformed weight data, weighted by their relative occurrence in the diet (see Jaksić and Braker 1983 for formula, justification, and assumptions of this trophic statistic). Prey sizes are mean weights of small mammals in Table 1. (b) Diet breadth — the diversity of prey in the diet as computed by Levins' (1968) index: $Bobs = 1/(\sum pi^2)$, where *pi* is the relative occurrence of prey taxon *i* in a given population's diet. This index generates values between 1 and *n* (when *n* resources are used equally). Because Levins' index increases with the number of prey taxa, a standardization is necessary when comparing populations in different localities, where the availability of prey taxa may differ. Colwell and Futuyma (1971) provide a standardized version of Levins' index: $Bsta$ = (Bobs - Bmin)/(Bmax - Bmin), where *Bobs* is the observed niche breadth (= Levins' index), *Bmin* is the minimum niche breadth possible (= 1), and *Bmax* is the maximum niche breadth possible (= *n*), which is the number of prey taxa actually taken by a given owl population (i.e., each of the taxa that receives a separate line in Table 1; generally, species for mammals and orders for insects). This standardized index renders values between 0 and 1 (i.e., between a comparatively narrow niche breadth, with disproportionately high representation of one or a few prey items, and a broad one, with a more even consumption of the available prey categories, respectively).

RESULTS AND DISCUSSION

Results are summarized in Table 1, and are here discussed in a north-south succession. In La Dehesa, the owls preyed upon all small mammals known to occur in the locality (see Jacksíc et al. 1981), with the exception of the rodents *Octodon degus* (a semi-fossorial species) and *Spalacopus cyanus* (a truly fossorial one). Jaksić and Yáñez (1980)

Table 1. Prey of Great Horned Owls in La Dehesa (33° S), Puerto Ibáñez (46° S), and Torres del Paine (51° S), Chile. Figures are percentages by number of prey individuals; subtotals are in brackets.

PREY CATEGORIES	WEIGHT(g)*	33°S	46°S	51°S
MAMMALIA		[88.6]	[86.0]	[87.5]
Lagomorpha				
Lepus capensis	2.000.0	——	5.3	0.6
Oryctolagus cuniculus	1,300.0	15.8	——	——
MARSUPIALIA				
Marmosa elegans	40.0	3.5	——	——
RODENTIA				
Abrocoma bennetti	219.0	18.4	——	——
Akodon lanosus	32.5	——	——	4.8
Akodon longipilis	76/41.0**	16.7	8.7	3.0
Akodon olivaceus	40.0	0.8	——	——
Akodon xanthorhinus	21.5	——	5.3	9.5
Ctenomys cf. *magellanicus*	271.8	——	15.8	——
Eligmodontia typus	26.5***	——	——	0.6
Euneomys chinchilloides	87.8***	——	26.3	0.6
Notiomys macronyx	——	——	——	2.4
Oryzomys longicaudatus	45/29.8**	4.4	1.8	39.8
Phyllotis darwini	66.0	4.4	7.0	——
Phyllotis micropus	75.0	——	12.3	——
Phyllotis sp.	——	——	3.5	——
Rattus rattus	158.0	19.3	——	——
Reithrodon physodes	81.7	——	——	25.6
Unidentified	——	5.3	——	0.6
AVES		[11.4]	[5.3]	[2.4]
Unidentified	——	11.4	5.3	2.4
INSECTA		[0.0]	[8.7]	[10.1]
Coleoptera	——	——	8.7	8.9
Hymenoptera	——	——	——	0.6
Orthoptera	——	——	——	——
Unidentified	——	——	——	0.6
No. pellets		98.00	55?	139.00
No. prey		114.00	57.00	168.00
Geometric mean prey weight (g)		181.9	104.5	41.1
Twice standard error		0.61	0.83	0.31
Sample size (= prey with weight)		95.00	47.00	142.00
Diet breadth *(Bobs)*		6.90	7.18	4.07
Standardized diet breadth *(Bsta)*		0.66	0.62	0.24

*Weights with no decimal places are from Jaksić and Marti (1984); all the remaining (except for those marked with asterisks) are from Jaksić et al. (1983).

**There is a strong latitudinal cline in body size for this species (see Yáñez et al. 1978, and Palacios 1982): the first figure corresponds to its mean weight in central Chile; the second, to its mean in southern Chile.

***From Greer (1965).

suggested that the absence of these 2 species from the Great Horned Owl diet was due to their diurnal-crepuscular activity pattern. In Puerto Ibáñez, owls preyed on essentially all small mammal species trapped by Reise and Venegas (1974) in the same locality, and on 2 additional rodents: *Euneomys chinchilloides* (a scansorial species) and *Ctenomys* cf. *magellanicus* (a fossorial one). These 2 made up more than 40% of the owls' diet (Table 1), but were neither trapped nor seen in the area (Reise and Venegas 1974; Yáñez et al. in press). In Torres del Paine, owls preyed on all small mammal species known to occur there, as well as on 3 other rodents hitherto not recorded (Rau et al. 1978): the terrestrial *Eligmodontia typus* and *Akodon lanosus*, and the semi-fossorial *Notiomys macronyx*. In general, the three owl populations studied preyed mainly on small mammals (averaging 87% of their prey). With increasing latitude, the proportion of birds in the diet decreased, with the opposite trend seen in the insect prey (from no insect consumption at all in La Dehesa, to 10% of the diet in Torres del Paine).

The geometric mean weight of prey declined monotonically from north to south, with no indication of a corresponding trend in owl body size (Johnson 1965; Humphrey et al. 1970). A similar (but not so consistent) decline in mean prey weight away from the equator was reported by Knight and Jackman (1984) for Great Horned Owls along the Pacific coast of the United States. Comparing areas at latitudes 30° to 40° between the two hemispheres, Jaksić and Marti (1984) showed that central Chilean and California Great Horned Owls did not differ significantly in body size (1,227 g vs. 1,166 g, respectively), but mean prey weight of California owls was 59% of Chilean ones. Knight and Jackman (1984) reported mean prey weight of Great Horned Owls in central Washington (46° N), which coincides with the latitude of Puerto Ibáñez. Because Knight and Jackman (1984) used an arithmetic estimate of mean prey weight, we recalculated from their raw data the geometric estimate, thus making their results comparable to ours. Washington owls exhibited a geometric mean prey weight of 22.9 ± 0.21 g (mean ± 2 s.e.; sample size = 872) which amounted to only 22% of the value reported for southern Chilean owls at the equivalent latitude (Table 1). It is difficult to assign causal relations to these patterns without knowing prey sizes available to owls in these different localities. Knight and Jackman (1985), following Herrera and Hiraldo (1976), speculated that the decrease in mean prey weight taken by owls at higher latitudes may be related to smaller prey becoming more abundant as latitude increases. We have no data to substantiate this claim.

Diet breadth in Chile also decreased with increasing latitude, in agreement with trends reported by Knight and Jackman (1984) for the Great Horned Owl along the Pacific coast of the United States and by Herrera and Hiraldo (1976) for the Eagle Owl *(Bubo bubo)* in Europe. Jaksić and Marti (1984) reported that central Chilean and California Great Horned Owls have a similar diet breadth at the class level of prey identification (H'NGG in their Table 3), but that the former have significantly narrower diet breadth at the species level of mammalian prey H'NM in their Table 3). Knight and Jackman (1984) documented a diet breadth of 4.12 (which amounts to a standardized diet breadth = 0.12; because $Bmax$ = 26, and $Bmin$= 1) for Washington Great Horned Owls. These values amount to 57% and 19% (respectively) of those computed for owls at the equivalent latitude in Chile, and are in fact more similar to observations 5 latitudinal degrees south, in Torres del Paine (Table 1). Apparently, both South and North American Great Horned Owls exhibit narrower diets toward higher latitudes, but the latter prey heavily on relatively few items. In fact, only two rodents *(Thomomys talpoides* and *Perognathus parvus)* accounted for 73% of the items in the diet of Washington owls. A similar value in the diet of Chilean owls was accounted for by the six most preyed upon rodent species in Puerto Ibáñez, and by three in Torres del Paine (Table 1). The decreasing diet diversity away from the equator might be related to a decreasing number of potential prey species which is consistent in both hemispheres.

Latitudinal trends in the trophic niche of Great Horned Owls along the Pacific coast of southern South America closely mirror trends documented in northern North America (and of the congeneric Eagle Owl in Europe). Local estimates of trophic statistics for latitudinally-matched localities in the two hemispheres, however, show some marked differences. The pattern of decreasing diet diversity away from the equator could have been expected, but a similar trend in mean prey weights at corresponding latitudes, both related to the local availability/vulnerability of prey, was unlikely to hold within/between the two hemispheres.

ACKNOWLEDGMENTS

We thank Richard J. Clark, Richard L. Knight, M. Ross Lein, Carl D. Marti, Martin K. McNicholl, Karen Steenhof, and an anonymous reviewer, for critically reading different versions of this paper. Jaksić acknowledges the support of grants DIUC 202/83 and 076/85 (awarded by the Pontificia Universidad Católica de Chile), and INT-8308032 (awarded by the U.S. National Science Foundation) during the several stages of preparation of the manuscript.

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Received 28 March 1986; Accepted 25 July 1986.

IMPACT OF A HIGH-VOLTAGE TRANSMISSION LINE ON A NESTING PAIR OF SOUTHERN BALD EAGLES IN SOUTHEAST LOUISIANA

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Abstract — To evaluate the impact of a 500th kv power transmission line on a pair of nesting bald eagles. *(Haliaeetus leucocephalus)* pre- and post-installation observations of eagle area-use were recorded. The mean of the daily proportion of eagle activity spent in the vicinity of the powerline decreased (P = 0.02) from pre-installation ($\bar{x}$=27.6%) to post-installation ($\bar{x}$=18.7%) seasons, indicating that activity patterns were changed after installation of the powerline. No serious physical threat to nesting eagles could be ascertained. The eagles regularly flew over and under the powerline, and perched and foraged near it. They never used the powerline itself for perching.

Wilcox (1979) reported on the success of a pair of Southern Bald Eagles *(Haliaeetus leucocephalus leucocephalus)* nesting 50 m from a 240th kv power line, however, quantitative data are unavailable on the effects of power transmission lines on territory use by nesting Southern Bald Eagles. The construction of a transmission line through the nesting territory of a pair of eagles in southeast Louisiana provided an opportunity to compare area-use by the eagles within the powerline zone before and after construction.

Study Area and Methods

The Waterford-Churchill 500-kV line passes through Salvador Wildlife Management Area (SWMA), St. Charles Parish, Louisiana, at the northwest shore of Lake Cataouatche, approximately 14 km south of New Orleans International Airport. The line consists of steel self-supporting towers of an "H" design. Each tower is 30.5 m tall and supports 3 phase conductors 9.6 m apart. The conductors vary from 11 to 21 m above marsh level. Two smaller static lines are strung approximately 9 m above the phase conductors. Distances between towers vary, but they are 265-274 m apart in the study area. The powerline is approximately 600 m north of the eagle nest studied and centered in a corridor approximately 60 m wide that has been cleared of all trees. Construction occurred during summer (when eagles are absent from SWMA) 1983.

The eagle nest is in a living bald cypress *(Taxodium distichum)*, 32.9 m high and 107.4 cm in diameter above the swelling at the base (Dugoni 1980). An observation blind was placed approximately 320 m north of the nest during 1983-84, between the nest tree and powerline. In 1979-80, the blind was approximately 100 m closer to the nest (Fig. 1). From the blind, we could observe eagles flying over an area of about 810 ha. This area was a nontidal, permanently flooded, palustrine system (Cowardin et al. 1979) occupied by forested wetland (cypress and *Nyssa aquatica*), aquatic bed *(Bidens laevis, Eleocharis* spp., and *Sagittaria lancifolia* on floating turf; *Nelumbo lutea* and *Eichhornia crassipes* were free-floating), and unconsolidated organic bottom habitats.

We observed eagles twice weekly from dawn to dusk and recorded total minutes spent in various activities and areas. To analyze the effect of the powerline on the eagles' area-use, a "powerline zone" extending 400 m to the south and up to 1000 m north of the powerline was defined within the study area. The boundaries of the zone were chosen to include the perch trees and foraging areas close to the powerline, and because the eagles had to cross the powerline to reach the most frequently-used foraging area visible from the blind. The proportion of "eagle-minutes" (combined number of minutes that both adults were observed) spent within the powerline zone each day was used as the dependent variable in a randomized-block design analysis of variance to test for differences between pre-and post-installation seasons (treatments) and among periods of the nesting season (blocks). The periods of the nesting season we blocked on were brooding, pre-fledging (eaglets still in nest, but not brooded), and post-fledging (eaglets out of nest).

Results and Discussion

Pre-installation observations were conducted from 3 January 29 to April 1980. During that season, 25 observation days were completed and 30,651 eagle-minutes were recorded (Shealy and Zwank 1981). Due to a lawsuit, construction of the powerline was delayed until summer 1983. Post-installation observations were for 4 January to 3 May 1984. Thirty-two observation days were completed, and 45,784 eagle-minutes were recorded.

The mean of the daily proportion of eagle-minutes spent by the adult eagles in the powerline zone decreased (P = 0.02) from pre-installation ($\bar{x}$=27.6 $\bar{x}$) to post-installation ($\bar{x}$=18.7%). Also, activity varied among the periods of the nesting season (P = 0.0004) (Table 1).

The eagles spent more of the brooding and pre-fledging periods in the powerline zone before installation than after. In the post-fledging period during both years, the eagles spent almost the same

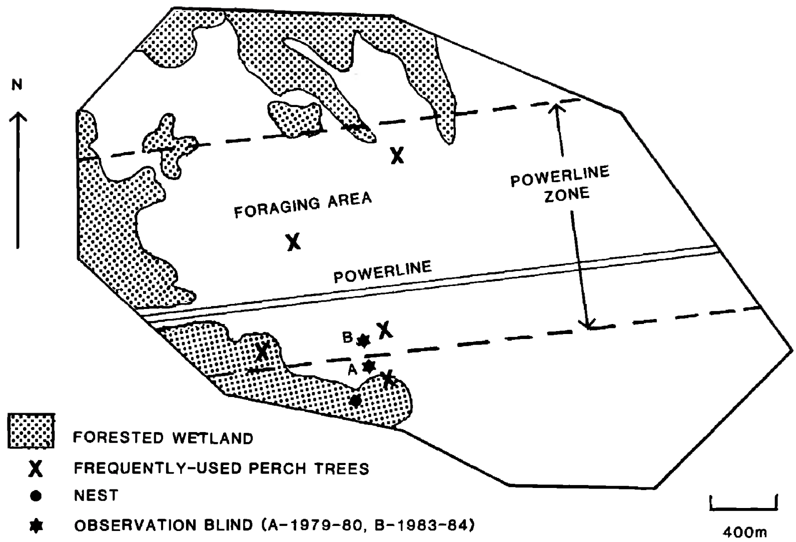

Figure 1. Area visible from eagle observation blind, Salvador WMA

proportion of time in the powerline area.

Activities within the powerline zone consisted of perching, soaring, foraging, or straight-line flight between perches. The eagles often flew over and under the conductors while going between the nest and various foraging areas. Herrick (1924) reported that one nesting pair of eagles regularly flew past "wires by the railroad."

We saw an eagle react to the powerline only once. While flying in circles 20-40 m above the marsh, an adult approached the wires several times, then banked quickly to avoid them. None of the eagles were ever seen perching on the transmission lines or towers.

Relocation of the observation blind in 1983 closer to a perch tree appeared to affect behavior. Use of this perch tree accounted for 1.3% of total activity in the pre-installation season (Shealy and Zwank 1981), but was never used during the post-installation season.

Table 1. Average daily proportion of eagle-minutes spent in the powerline zone in 1979-80 and 1983-84 and averages by nest period.

PERIOD	$\bar{X}$	SE	N[a]	CV%
1979-80	0.276	0.0350	25	63.3
Post-fledging	0.400	0.2006	4	100.3
Pre-fledging	0.254	0.251	14	37.0
Brooding	0.250	0.0386	7	40.9
1983-84	0.187	0.0418	32	126.7
Post-fledging	0.411	0.0806	11	65.0
Pre-fledging	0.082	0.0315	13	139.0
Brooding	0.048	0.0151	8	88.4

[a]Observation days.

Changes in area-use observed may have resulted from removal of potential perch trees from the powerline corridor, blocking of forage flights by transmission wires or changes in prey availability or distribution. Replacement of one or both members of the adult pair could also have influenced behavior; we cannot be certain that the same pair nested in both 1980 and 1983. Also, relocation of the observation blind changed perching habits, but its influence on use of the powerline zone could not be determined.

Based on our observations of eagles during flight, we do not think the powerline poses a serious physical threat to the nesting adults. Also, nesting attempts were successful before and after powerline installation. Possibly, however, awkward fledglings could collide with the powerline. Eagle electrocutions are unlikely because phase conductors are widely spaced (9.6 m) and we never observed perching on the powerline or towers.

FUNDING

This article is a contribution from the La. Coop. Wildl. Res. Unit (USFWS, La. Dept. Wildl. and Fisheries, La. State Univ., Wildl. Manage. Inst., and School of Forestry, Wildl., and Fisheries, LSU cooperating). Funding was provided by Louisiana Power and Light Co.

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Received 15 December 85; Accepted 15 June 1986.

Third New England Regional Hawk Conference - The New England Hawk Migration Committee wishes to announce the Third New England Regional Hawk Conference will be held 4 April 1987 at the Holiday Inn, Holyoake, Massachusettes. Registration forms are available from HAWKS, P.O. Box 212, Portland, Connecticut 06480. There are special rates available for lodging at the Conference center. Registration will be limited.

FOOD OF THE BOOTED EAGLE *(HIERAAETUS PENNATUS)* IN CENTRAL SPAIN

JOSÉ P. VEIGA

ABSTRACT. — The identification of 202 prey remains of the Booted Eagle *(Hieraaetus pennatus)* shows that mammals (41.6% of prey items identified), birds (36.6%) and reptiles (21.8%) are important prey in Central Spain. Most mammals captured were young rabbits, and the majority of the bird prey were fledglings or juveniles. Lizards were adult or subadult individuals. Over 90% of the prey captured weighed between 27 and 243 g.

Little is known about the biology of the Booted Eagle *(Hieraaetus pennatus),* as it occurs in countries with little ornithological activity. Most published accounts of food habits are single enumerations of prey remains recorded mainly during sporadic visits to nests (Valverde 1967; Araújo 1973; Garzón 1973; Iribarren 1975). This procedure provides an inaccurate picture of diet, since prey that are large and leave persistent remains are over-represented in samples (e.g., Valverde 1967; Delibes 1975). In spite of this, several recent papers dealing with the trophic relationships between members of various raptor communities have made use of such data (Jaksić and Soriguer 1981; Jaksić 1983; Jaksić and Braker 1983). In my opinion this has led to erroneous conclusions regarding the ecological position of the Booted Eagle in Mediterranean environments. The present paper presents more accurate information about the diet of this raptor, obtained using a more systematic data collection procedure. I also take into consideration some attributes of prey, such as size and age, that have been overlooked.

STUDY AREA AND METHODS

This study was carried out in 3 areas, each about 35 km^2 in size, located on the northern slope of the Sierra de Guadarrama mountains (40° 35′-40° 60′ N, 0° 5′-0° 60′ W). Area 1 is about 60% pasture interspersed with thick scrub. The only arboreal formations present are 3 small pine groves of between 1 and 5 ha. Area 2 is 10 km away and about 40% covered with mature natural pine trees *(Pinus silvestris)* over 15 m tall. The rest of area 2 is made up of a sparse evergreen oak grove *(Quercus rotundifolia)* with extensive clearings in which low scrub mixes with pasture land. Area 3, 15 km from area 2 and 30 km from area 1, is similar to area 1 in that it has only 2 arboreal formations, one of 2 ha and the other of 25 ha.

Area 1 was visited from 1978 to 1981. One pair of Booted Eagles used the same nest year after year. Area 2 was also visited from 1979 to 1981. In 1979 2 pairs of nesting eagles were present, but in 1980 to 1981 no nests were found. Area 3 was also visited from 1979 to 1981. In both 1979 and 1980 1 pair of eagles was located, but no eagles were seen in 1981. Visits were made approximately every 15 d from shortly before incubation (mid-late April) until after the young left the nest (mid-late August). During the feeding period nests were occasionally visited every 7 d. Pellets and prey remains were sought in and around nests and below perches which were usually within a 200 m radius of the nests.

A total of 110 pellets, containing 130 identifiable prey items, and 72 prey remains were collected. Each species found in any one pellet was counted as 1 individual unless it was possible to show that more than 1 was represented. Therefore, it was necessary to count pieces of remains such as nails, beaks, teeth, etc. Weight and approximate age of the prey were estimated by comparing remains with material from zoological collections and with specimens collected in the study areas. In order to establish a frequency distribution for prey, weight classes were established whose limits followed a geometric progression (Fig. 1). This insured that the resulting distribution would be more or less normal (Schoener 1969; Hespenheide 1971). Only some prey identified in the pellets could be assigned to one of the established weight categories, particularly in the case of species, like rabbits and ocellated lizards, whose weights vary a great deal.

RESULTS AND DISCUSSION

Mammals, birds, and reptiles, in decreasing order of capture frequency, comprised the diet of the Booted Eagle in the study area. Percentage differences of these taxa in the diet increased considerably when biomass was taken into account. (Table 1). Among mammal prey, rabbits were the most important prey species. Birds captured were primarily species that forage on the ground. The Ocellated Lizard *(Lacerta lepida)* was the only reptile prey, although other lizards are common in the study area.

The weight of prey items varied between 10 and 800 g. However, most were in the 27 to 243 g range (Fig. 1). A major part of the diet consisted of prey in the 81 to 243 g weight-class (Fig. 1). Prey-size distributions do not appear to be the same for the 3 taxa present in the diet: most mammal and lizard prey weighed between 81 and 243 g. Avian prey was

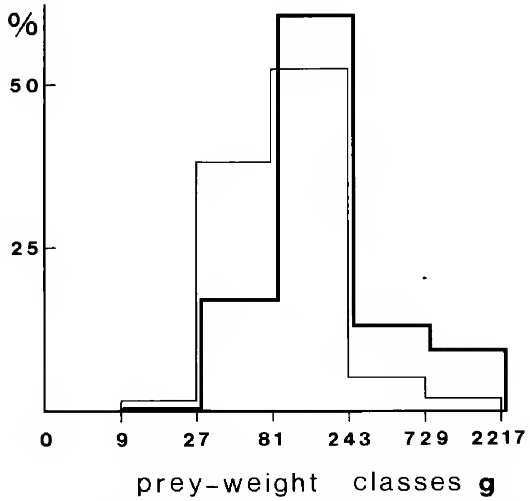

Figure 1. Diet of the Booted Eagle. Thick line histogram: percent of the total biomass supplied by the prey-items; thin line histogram: percent of the total number of prey-items. Sample size = 165.

predominantly between 27 and 81 g (Fig. 2). The majority of birds in this class were the Spotless Starling, *(Sturnus unicolor)* weighing 70 g. Nearly all rabbits captured were very young individuals. Of 27 bird prey items of known age, the number of fledgling and juveniles was greater than the number of adults (22 young vs. 5 adults). All Ocellated Lizards identified were adults or sub-adults.

Prey-size distribution could merely reflect the size distribution of available prey, assuming Booted Eagles on the study area selected prey randomly with respect to size. Nevertheless, the lack of insects, amphibians, and small reptiles in the diet of some other raptors of similar size such as the Common Buzzard *(Buteo buteo),* Black Kite *(Milvus migrans)* and Red Kite *(M. milvus)* in the same study area (Veiga 1982) suggests that prey below a certain weight were avoided. Prey might also be selected according to age and experience. This may be particularly true for avian prey, since the poor flying abilities of young birds make this age class more vulnerable to predation by Booted Eagles.

It has been reported that the analysis of pellets and prey remains for Order Falconiformes tends to underestimate the amount of some prey while overestimating others (Valverde 1967; Delibes 1975; Collopy 1983). The absence of small prey such as insects, amphibians or small reptiles in the Booted Eagles' diet could be due to these methodological biases. However, using the same methodology, these small prey have been found in the diet of other similar sized raptors in the same areas in which the Booted Eagle was studied, Furthermore, by sampling prey remains regularly and at relatively short intervals the potential bias possibly caused by the greater detectability of certain prey when collected at longer intervals would be diminished. The fact that the material to be analyzed was collected from the nests as well as from the perches of the adults reduces the possibility of obtaining a distorted image of diet if it is assumed that food taken to the nestlings is different from that of the adults. I have not been able to demonstrate this in the Booted Eagle.

Earlier studies of Booted Eagle feeding habits carried out in the Palearctic and in South Africa describe them as a hunter of small birds and, to a lesser degree, lizards (Valverde 1967; Araújo 1973; Garzón 1973; Iribarren 1975; Steyn and Grobler 1981). It is worth noting that although the scarcity of mammals in the South African Booted Eagles' diet could be due to a lack of appropriate sized individuals in the field, the low representation of this taxon in reports from Spain where rabbits abound in a variety of sizes is surprising. My results suggest that the Booted Eagle behaves, in my study

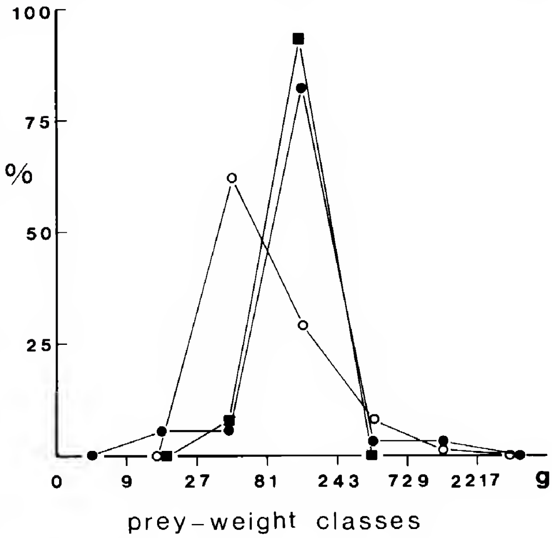

Figure 2. Distribution of the prey remains in the prey-weight classes in each taxonomic group., Black circles = mammals; open circles = birds; squares = reptiles. Sample sizes: mammals = 61; birds = 64; reptiles = 40.

Table 1. Prey of the Booted Eagle in central Spain.

Species	Number of Items	Occurrence Percent	Biomass Percent
Reptiles			
Ocellated Lizard *(Lacerta lepida)*	44	21.8	14.3
Total	44	21.8	14.3
Birds			
Common Kestrel *(Falco tinnunculus)*	2	0.99	1.0
Quail *(Coturnix coturnix)*	2	0.99	0.46
Unidentified Phasianidae	1	0.49	0.46
Little Bustard *(Otis tetrax)*	1	0.49	1.76
Stone Curlew *(Burhinus oedicnemus)*	1	0.49	1.05
Wood Pigeon *(Columbia palumbus)*	1	0.49	1.08
Unidentified Columbidae	3	1.48	2.54
Swift *(Apus apus)*	1	0.49	0.09
Hoopoe *(Upupa epops)*	7	3.46	1.03
Green Woodpecker *(Picus viridis)*	1	0.49	0.39
Unidentified Alaudidae	1	0.49	0.08
Mistle Thrush *(Turdus viscivorus)*	1	0.49	0.27
Spotless Starling *(Sturnus unicolor)*	28	13.86	5.13
Magpie *(Pica pica)*	9	4.45	4.33
Jackdaw *(Corvus monedula)*	4	1.98	2.1
Carrion Crow *(Corvus corone)*	1	0.49	1.18
Unidentified	10	4.95	1.83
Total	74	36.6	24.8
Mammals			
Common White-toothed Shrew *(Crocidura russula)*	1	0.49	0.03
Blind Mole *(Talpa caeca)*	2	0.99	0.19
Rabbit *(Oryctolagus cuniculus)*	65	32.18	48.71
Hare *(Lepus granatensis)*	2	0.99	5.0
Unidentified Lagomorpha	1	0.49	0.75
Water Vole *(Arvicola sapidus)*	8	3.96	5.0
Weasel *(Mustela nivalis)*	3	1.48	0.94
Unidentified	2	0.99	0.19
Total	84	41.6	60.8
Total Items	202		

area, like a taxa-generalist that concentrates on terrestrial prey weighing between 70 and 240 g. It is probable that the general decrease of the rabbit in Iberian ecosystems in the last decades, resulting from the effect of mixomatosis, has influenced the composition of the Booted Eagle's diet. However, there are no detailed studies of the population dynamics of the rabbit and other prey species, which would be necessary before this could be seriously discussed.

ACKNOWLEDGMENTS

I am indebted to G. Bortolotti, C. Griffin and B. Millsap for their critical comments of an earlier draft.

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Received 30 March 1985; Accepted 8 April 1986.

FOODS OF NESTING BALD EAGLES IN LOUISIANA

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Abstract — During the summer of 1979, remains of 243 vertebrates comprising 31 species were collected from 10 nests that had fledged young during the previous spring to determine the food habits of nesting Bald Eagles (*Haliaeetus leucocephalus*) in Louisiana. American Coots (*Fulica americana*) and freshwater catfish (*Ictalurus* spp.) were the most abundant species, but fish probably constituted a greater portion of the diet than results indicate, due to more complete digestibility of piscian skeltons.

The Bald Eagle (*Haliaeetus leucocephalus*) nests in swamps of southcentral and southeastern Louisiana. Portions of this habitat are being lost or altered due to drainage, channelization conversion of land to agriculture, and industrial development (Yancey 1970). Loss of swamp habitat may harm nesting eagles by reducing the availability or abundance of prey. Support for this hypothesis is provided by McEwan (1977) who found that Bald Eagles in Florida rely primarily on fish and wetland birds for food. Foods of nesting Bald Eagles in Louisiana have not been previously documented.

Study Area and Methods

Fieldwork was conducted in coastal southeastern and southcentral Louisiana, including Terrebone, Jefferson, St. Charles, St. Tammany, and Assumption Parishes. Climate is subtropical maritime. Wetlands of 0-2 m elevation predominate; relief is provided by levees and spoilbanks. Much of the region consists of permanently or annually flooded baldcypress (*Taxodium distichum*) - tupelogum (*Nyssa aquatica*) forests. Dominant land uses include gas and oil production and industrial development, as well as hunting, fishing and trapping. Area vegetation and other characteristics are further described by Bahr et. al. (1983) and Chabreck and Condrey (1979).

Bald Eagle nest locations were determined in 1977 and 1978 by interviews with private citizens and by using helicopter surveys. In June and July 1979, immediately following fledging of young and seasonal departure of parents, prey remains were collected from 9 nests. Additional remains were collected in July from a nest after it was downed by a hurricane. To ensure as much as possible that prey remains were those left by 1979 nesters, we collected only those remains on or near the nest surface immediately after eagles vacated the nest, prior to possible nest use by other species.

Results

Prey species of nesting Bald Eagles were determined from remains found in 10 nests during the summer of 1979. We collected remains of 243 vertebrates, including 4 classes and 31 species (Table 1). Birds comprised the highest percentage of prey animals (42.4%), followed by fish (41.5%), mammals (15.7%), and a reptile (0.4%). American Coots (*Fulica americana*) comprised 40 (47.6%), of the 103 birds, while freshwater catfish (*Ictalurus* sup.) accounted for 53 (52%) of 101 fish. Muskrat (*Ondatra zibethicus*) and Nutria((*Myocastor coypus*) combined comprised 82.2% of mammals, and the reptile remains were those of a Mud Turtle (*Kinosternon subrubrum*).

Discussion

Remains of 31 vertebrate prey species may support claims that Bald Eagles are opportunistic feeders (Retfalvi 1970; Todd et. al. 1982; fielder 1982). However, American Coots and catfish made up nearly 42% of prey animals, indicating that a preference for these species may exist. Our findings agree with those of McEwan (1977), who found that American Coots and catfish comprised the major portions of the diet of Bald Eagles in Florida. Fielder (1982) reported that American Coots were the major prey animal of Bald Eagles at a study site in Washington, but concluded that availability of prey dictated usage. Haywood and Ohmart (1986) found in Arizona that, while catfish and other benthic-feeding fish comprised the majority of prey, American Coots were the major avian prey of Bald Eagles. Benthic fish are common prey probably because of their high vulnerability to aerial predators (Todd et. al. 1982). Bald Eagle consumption of benthic fish, American Coots, and dabbling waterfowl makes obvious the importance of shallow wetlands within foraging distance of nest sites. Because of this importance, proposals to alter such wetlands should be carefully studied.

A bias toward nonfish prey species probably exists in our study, because fish skeletal parts can be more completely digested than those of other vertebrates (Todd et. al. 1982). For instance, although we observed over 20 Gizzard Shad (*Dorosoma cepedianum*) brought to nests and consumed, the remains of only 2 were recovered.

Table 1. Species identified from remains collected from 10 Louisiana Bald Eagle nests after the 1978-1979 nesting season.

CLASS MAMMALIA			CLASS AVES			CLASS OSTEICHTHYES			CLASS REPTILIA		
SPECIES	No.	%	SPECIES	No.	%	SPECIES	No.	%	Species	No.	%
Ondatra zibethicus (Muskrat)	18	7.4	*Fulica americana* (American coot)	49	20.2	*Ictalurus* spp. (Freshwater Catfish)	53	21.8	*Kinosternon subruburm* (Mud Turtle)	1	0.4
Myocastor coypus (Nutria)	14	5.8	*Anas fulvigula* (Mottled Duck)	11	4.5	*Amia calva* (Bowfin)	10	4.1	Subtotals	1	0.4
Sylvilagus floridanus (Eastern Cottontail)	4	1.6	*Anas discors* (Blue-winged Teal)	10	4.1	*Aplodinotus grunniens* (Freshwater Drum)	10	4.1			
Sylvilagus aquaticus (Swamp Rabbit)	2	0.8	*Gallinula chloropus* (Common Gallinule)	8	3.3	*Mugil* cephalus (Striped Mullet)	5	2.1			
Subtotals	38	15.6	*Aythya americana* (Redhead)	4	1.6	*Cyprinus carpio* (Carp)	5	2.1			
			Anas strepera (Gadwall)	4	1.6	*Micropterus salmoides* (Largeouth Bass)	5	2.1			
			Anas acuta (Pintail)	3	1.2	*Arius felis* (Sea Catfish)	3	1.2			
			Aythya valisneria (Canvasback)	3	1.2	*Dorosoma cepedianum* (Gizzard Shad)	2	0.8			
			Podilymbus podiceps (Pied-billed Grebe)	3	1.2	*Strongylura marina* (Atlantic Needlefish)	2	0.8			
			Aix sponsa (Wood Duck)	2	0.8	*Lepisosteus osseus* (Longnose Gar)	1	0.4			
			Anas Americana (American Widgeon)	1	0.4	Subtotals	101	41.6			
			Anas platyrhynchos (Black Duck)	1	0.4						
			Rallus virginia (Virginia Rail)	1	0.4						

Class Mammalia			Class Aves			Class Osteichthyes			Class Reptilia		
Species	No.	%	species	No.	%	Species	No.	%	Species	No.	%
			Rallas elegans (King Rail)	1	0.4						
			Larus delawarensis (Ring-billed Gull)	1	0.4						
			Subtotals	103	42.4						

ACKNOWLEDGMENTS

Contribution of the Louisiana Cooperative Fish and Wildlife Research Unit; Louisiana State University, U.S. Fish and Wildlife Service, Louisiana Department of Wildlife and Fisheries, and Wildlife Management Institute, cooperating. We wish to thank Dr. John V. Conner, Professor, Louisiana State University, and Dr. Royal B. Suttkus, Director, Tulane University Museum of Natural History, for help in identification of specimens. We thank Mr. John D. Newsom, Leader, Louisiana Cooperative Wildlife Unit, retired, for guidance during the early stages of this study, and thank the U.S. Army Corps of Engineers for financial support.

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Received 1 February 1986; Accepted 31 October 1986.

MALE FOOD PROVISIONING AND FEMALE REPRODUCTION IN AMERICAN KESTRELS

Timothy J. Coonan

While the effects of male raptor nest provisioning on clutch quality have been documented (Drent and Daan 1980; Wink et. al. 1980), the effect of provisioning on later nest success is less well established. Male provisioning ability should affect hatching and fledging success, since the female and young of many raptor species depend to a degree on the male for food delivery until fledging (Balgooyen 1976; Snyder and Wiley 1976; Newton 1978; Mueller et. al 1981; Rudolph 1982; and Village 1983).

The purpose of this study is to document the relationship between male provisioning performance and pair reproductive success, beyond clutch size, in the American Kestrel *(Falco sparverius)*. Effects of differential male provisioning performance should be seen in number of young hatched and number of young fledged from each nest.

MATERIALS AND METHODS

Six kestrel pairs in wooden nestboxes (Gary and Morris 1980) were observed from the pre-hatching to fledging stage in the Coconino National Forest near Flagstaff, Arizona, in June and July 1982. The study area was primarily ecotonal within the ponderosa pine *(Pinus ponderosa)* forest of the Transition Life-zone (Lowe 1964). Stands of ponderosa pines were interspersed with more open areas of one-seed juniper *(Juniperus monosperma)*, Gambel's Oak (*Quercus gambelli*), squawbush (*Rhus trilobata*), prickly pear cactus *(Opuntia* spp.), Parry rabbitbrush *(Chrysothamnus parryi)*, and blue grama grass *(Bouteloua gracilis)*. Elevation in the study area ranged from 2070 to 2160 m.

Observations were made with 7-15x binoculars or 20-60x spotting scope, 100 to 200 m from each nest. Nests were observed in 2 to 8 h shifts between 0800 and 1800 h. Kestrels did not forage appreciably before 0800 h, perhaps due to the inactivity of orthopterans, their principal prey.

Wind velocity can affect kestrel foraging strategies and success (Rudolph 1982; Village 1983). My observations were confined to relatively calm days, since windy days added too many variables to adequately measure its effect on provisioning.

Two hundred fifty-nine male and female provisioning trips to the nest were documented. Percent male and female provisioning and male and female prey deliveries/hr were calculated for each nest. Clutch size (determined just prior to hatching), number of young hatched and number of young fledged were recorded for each nest. Male and female prey deliveries/chick/hr were calculated for each nest.

Spearman's rank correlation procedure (Zar 1974) was used to analyze data. A significance level of 0.05 was used in all tests.

Results and Discussion

Males contributed an average of 44.32% of the food deliveries to the nest from hatching to fledging. Individual males, however, varied in their contributions relative to the female (Table 1). Percent male provisioning ranged from 18.0 to 67.1%. Male prey deliveries/hr ranged from 0.60 to 2.80 and was significantly correlated with percent male provisioning ($r_s = 0.943$, $P < 0.025$). Clutch size, number of young hatched and number of young fledged were each significantly correlated with male prey deliveries/hr ($r_s = 0.843$, $P < 0.05$; $r_s = 0.843$, $P < 0.05$; $r_s = 0.929$, $P < 0.025$).

Balgooyen (1976) found that the female provided 71.1% of the food deliveries to one nest during the period after hatching when both male and female hunt. Females in this study during the same period provided an average of 54.02% of the prey deliveries ($n = 6$), though there was high individual variation in female provisioning. Female prey deliveries/hr ranged from 0.64 to 2.73 (Table 1).

Neither female prey deliveries/hr nor total prey deliveries/hr correlated significantly with number of young fledged ($r_s = 0.500$, $P > 0.10$; $r_s = 0.014$ $P > 0.25$). Spearman r_s between total prey deliveries/chick/hr and persent fledged was 0.629. While not significant ($P > 0.10$), this suggests that higher feeding rates result in higher chick survival.

Spearman's r_s between male and female prey deliveries/hr was -0.657 ($P = 0.10$), suggestive of a negative correlation. Males and females of individual pairs may adjust their prey delivery rates relative to their mate's abilities.

The individual variation in male provisioning correlated with several measures of nest reproductive success. Those males which delivered a greater number of prey/hr appeared to realize a higher immediate reproductive success of young hatched and fledged.

Other factors could account for the observed results. First, data were insufficient to evaluate quality of prey delivered by males or females. Some males may have provided relatively more vertebrates to their mates and broods than did others. The

Table 1. Male and female nest provisioning performance and female reproduction for six American Kestrel nests, northern Arizona, 1982.

	Percent Provisioning		Prey Deliveries/hr			Prey Deliveries/chick/hr					
Nest	Male	Female	Male	Female	Total	Male	Female	Total	Clutch Size	Young Hatched	Young Fledged
1	67.1	22.9	1.31	0.64	1.95	0.262	0.128	0.390	5	5	4
2	52.4	47.6	0.85	0.77	1.62	0.170	0.154	0.324	5	5	3
3	18.0	82.0	0.60	2.73	3.33	0.200	0.910	1.110	4	3	2
4	25.0	75.0	0.71	2.13	2.84	0.355	1.065	1.420	3	2	2
5	43.8	56.2	0.82	1.05	1.87	0.273	0.350	0.623	4	3	2
6	59.6	40.4	2.80	1.90	4.70	0.560	0.380	0.940	5	5	4

energetic advantage this could confer is substantial; Bird et. al. (1982) estimated 1 vole contained about 125 times more energy than 1 grasshopper.

Second, clutch size and brood size were each correlated with male prey deliveries/hr. Perhaps males adjusted their respective rates of prey delivery according to the brood size for which they had to provide. Testing for such a functional response would require comparing male delivery rates before and after hatching. Data were insufficient to evaluate this possibility. However, male prey deliveries/chick/hr was not correlated with brood size (r_s -0.129, $P > 0.50$), indicating that male prey delivery rates to individual chicks were the same for large and small broods. This suggests that males respond functionally to larger broods by providing prey items at a higher rate. In contrast, female prey deliveries/hr was not significantly correlated with brood size ($r_s = 0.554$, $P > 0.10$), indicating that females do not respond functionally to larger broods by increasing their rates of prey delivery.

The variability in male and female prey delivery rates could have resulted from other factors, such as age or experience of the bird (see Newton 1979) or territory quality (Newton 1976; Rudloph 1982). A final possibility is that smaller size and lower wing-loading of some males provided them with greater energetic efficiency (Balgooyen 1976; von Schantz and Nilsson 1981). These factors were not measured.

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Received 8 October 1985; Accepted November 1986.

SHORT COMMUNICATIONS

Success Rates of the Peregrine Falcon (*Falco peregrinus*) Hunting Dunlin (*Calidris alpina*) During Winter

Joseph B. Buchanan, Steven G. Herman and Tod M. Johnson

The Peregrine Falcon *(Falco peregrinus)* utilizes a wide variety of prey types (Ratcliffe 1979; Cade 1982) throughout its nearly cosmopolitan distribution. In addition, it also exhibits a huge range (7-83%) of success rates for hunting flights (see Roalkvam 1985 for review). Success rates of hunting flights during winter periods have been reported by Lindberg (1975), Clunie (1976) and Roalkvam (1985); however, data on success rates for specific prey species or prey type are lacking. Here we present data for rates of success when Peregrines hunted Dunlin *(Calidris alpina)* during the winter (December-March).

During the winters of 1979-1981, while studying the ecology of the Dunlin in western Washington, we observed hunting flights directed at this species by peregrines. Hunting flights were observed at the Samish River Delta, in northern Puget Sound, and at Bowerman Basin and 2 other estuarine sites located in Grays Harbor on the outer coast. Subadult and adult male and female Peregrines of 2 subspecies, *F. p. pealei* and *F. p. anatum,* were observed hunting Dunlins. A description of behavioral interactions between Dunlins and their falcon predators [Peregrines and Merlins *(F. columbarius)*] will be presented elsewhere.

We define a hunting flight as a perch-to-perch flight involving one or more capture attempts at suitable prey. A capture attempt is defined as an individual effort to capture a specific individual during a hunting flight.

We observed 17 hunting flights directed at Dunlins, 15 of which had known outcomes. Peregrines were successful at capturing Dunlins from a stoop and when pursuing individuals in a low direct chase. Stoops were used in 11 (65%) hunting flights. In 2 flights these were high stoops, originating from heights of 1000 m or more. Other stoops originated from 50-80 m. Feint stoops were observed only twice. Of 47 capture attempts, 33 (70%) were stoops at flocks, 6 (13%) were low chases of single Dunlins and 8 (17%) were horizontal attacks of flocks.

The success rate for hunting flights was 47% (n= 7) while the rate for capture attempts was 14.6%. Five flights (33%) were successful on the first capture attempt. A stoop was used in 3 of these hunts, and low chase after a single Dunlin in the other 2. Seventy-one percent of the successful hunts were successful on the first capture attempt. All but one successful hunt involved in-flight prey capture.

The success rate (47%) which we observed was significantly greater than the winter rate of 9.6% reported by Clunie (1976) ($\chi^2 = 7.9$, df = 1; $0.001 < P < 0.005$) or the 13.7% reported by both Lindberg (1975) and Roalkvam (1985) ($\chi^2 = 11.6$; df = 2; $0.001 < P < 0.005$). Dekker (1980) presents data for success rates in regard to fall hunting flights directed at shorebirds (9.0%), although his data obviously refer to migrant falcons.

The high success rate of hunting flights which we observed, relative to these studies, might be explained in two ways. First, if a falcon is unfamiliar with a site that it seldom visits (e.g., during migration) success rates for hunting flights might be expected to be lower than for falcons which maintain winter territories. Secondly, the high success rate we observed was related to the success rate of the initial capture attempt, which at 71% for suc-

cessful hunts means that few falcons continued to hunt after the first attempt. This is not surprising since a certain trade-off must exist between reasonable energy expenditure and profitable caloric intake.

Cade (1982) states that Peregrines will not stoop into a massed flock of birds. We found, however, that a stoop into a compact flock was the most common technique used by Peregrines hunting Dunlins in western Washington. The rarity of the high stoop may be related to the apparent ease with which Peregrines capture Dunlins using other techniques. Also, such an effort may be energetically inefficient considering the probable low caloric value of a small species such as the Dunlin.

ACKNOWLEDGMENTS

We thank L. A. Brennan, A. M. Cahall, M. A. Finger, and C. T. Schick for their assistance in the field. C. M. Anderson contributed in many ways and provided valuable discussion on the topic of definitions for hunting flights and capture attempts. Funding during the winter of 1980-81 was provided by NSF-SOS Grant SPI80-04760. The manuscript was improved by comments from D. A. Boyce, S. K. Sherrod and C. M. White.

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Received 7 April 1986; Accepted 25 July 1986.

Golden Eagle Capture of an American Coot

Daniel J. Severson

Previous food habit studies of the Golden Eagle *(Aquila chrysaetos)* list the American Coot *(Fulica americana)* as a prey item (Dixon, *Condor* 39:49-56, 1937; Olendorff, *Am. Midl. Nat.* 95:231-236, 1976; Bloom and Hawks, *Raptor Res.* 16:110-115, 1982; Marr and Knight, Murrelet 64:73-77, 1983). Dixon (1937) reported several observations of Golden Eagles capturing coots. The eagle positioned itself between the lake and the coots, using natural barriers to conceal its approach, and then quickly attacked its prey. Dixon believed that this was a learned method that was often used.

On 14 April 1982 at ca 0900 H near Malheur Lake in southeastern Oregon, accompanied by M. Rule, I observed an estimated 500 coots feeding in a partially flooded alfalfa field bordering Malheur Lake. I also observed a Golden Eagle flying directly toward the coots at a height of 20 m. The coots began running toward the lake when the eagle was within ca 200 m. The eagle flew over the coots, turned into the wind and briefly hovered, holding its position as they passed underneath. The eagle made 2 unsuccessful dives at the coots before capturing one on the

third attempt starting from a height of ca 2 m. The eagle then stood on the coot for about 30 sec before flying north for 50 m and accidently dropping its prey in the water, where the coot was observed splashing in the water. The eagle immediately flew down, picked up the coot and flew to a fence post 50 m away and 3 min later began feeding.

Collopy (*Auk* 100:747-749, 1983) found that Golden Eagles typically orient into the wind, presumably to reduce flight speed and to attack prey from close quarters. The same technique apparently was used by the eagle in this observation.

I thank M. Collopy, D. Garcelon and J. Houk for reviewing and commenting on the manuscript.

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Received 20 February 1986; Accepted 15 June 1986

Bilateral Bumblefoot in a Wild Red-Tailed Hawk

Kevin L. Ellis

Bumblefoot is the falconer's term for any abnormal enlargement of a raptor's foot or a portion thereof. It is the most common clinical condition associated with captive raptors (Riddle, K., Recent Advances in the Study of Raptor Diseases, London, 1980). Raptors with high wing-loading, such as the larger falconids, seem more prone to the condition than other hawks with lower wing-loading (Halliwell, W., *J. Zoo. Anim. Med.* 6 (4): 8-10 1975). Bumblefoot in captive raptors is most often management related; usually caused by improper perches (Riddle, 1980).

Figure 1: Swollen metatarsal pad and digits on both feet.

Bumblefoot often starts when the integument of the metatarsal pad is injured and inflammation results. Inflammed areas then may become infected resulting in formation of an abscess. Continued trauma to the infected area may cause the fissure of abscess material into surrounding uninfected areas. The disease will often continue to spread until much of the foot is infected. In many cases bumblefoot is followed by osteomyelitis and/or septicemia, endocaritis, and finally death (Riddle, 1980). Bumblefoot can also be directly caused if the foot is punctured by a talon or other sharp object. Bacterial agents associated with bumblefoot as secondary agents include *Staphylococcus* spp., *Escheria coli*, *Streptococcus* spp. and *Clostridium* spp. Fungi have also been associated with bumblefoot in-

fections (Cooper, J.E., Veterinary Aspects of Captive Birds of Prey, Standfast Press, England, 1978).

The condition may be unilateral or bilateral and in less severe cases can heel without clinical treatment if the underlying cause is removed. If the lesion becomes infected, however, surgical treatment is often necessary, and the success rate may be very high (Riddle, 1980).

To my knowledge no case of bumblefoot in a wild raptor is documented in the literature, however, it has been observed. Brian Cade and Clayton White (pers. comm.) banded a female nestling Peregrine Falcon *(Falco peregrinus)* on the Colville River, Alaska, in July that had severe bumblefoot. It was trapped on Holly Beach, Louisiana, in October of the same year. The trapper made no mention of its swollen feet at that time. Pat Redig (pers. comm.) has seen bumblefoot in wild Bald Eagles *(Hallaeetus leucocephalus)* 1 Prairie Falcon (*Falco mexicanus*), 1 Rough-legged Hawk (*Buteo lagopus*), and Red-tailed Hawks (*Buteo jamaicensis*). In all cases the birds had an injury to the other leg; usually a missing foot from a trap. The purpose of this note is to report bilateral bumblefoot in a wild Red-tailed Hawk.

On 10 March 1985 I received a report of an injured hawk along the Pine River (La Plata County, Colorado). Upon arriving to the area, I located an adult Red-tailed Hawk which was barely able to fly. Upon capturing the bird, I noted that the metatarsal pad, as well as all digits, of the bird's feet were severely swollen (Figure 1). The right foot had a scabbed over puncture wound above and between digits III and IV. The hawk was severly emaciated and could not move the digits of either foot. Immediately after euthanasia, I made an incision into the metatarsal pad of the right foot. A large amount of casious exudate was located around the tendon. Culturing of this material yielded *E. Coli.* Although not known for sure, it is probable that the infection entered through the aforementioned puncture wound and spread to other areas, becoming so acute that the bird was unable to catch prey items and thus its physical condition deteriorated.

ACKNOWLEDGEMENTS

I wish to thank Clayton White and Pat Redig for their comments on the manuscript. Linda Eskridge and Dixie Simmons also provided assistance.

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Received 15 April 1986; Accepted 1 September 1986.

NEWS AND REVIEWS

Report — 1st International Symposium on the Golden Eagle. On 14-15 June 1986, the 1st International Symposium on the Golden Eagle was held in Brunissard, French Alps. It was organized by The Alpine Research Centre for Vertebrates, the Queyras Regional Nature Park, the Ecrins National Park, and the Mercantour National Park. The organizing committee was chaired by Samuel Michel from the Alpine Research Centre for Vertebrates.

In France, the concern about the Golden Eagle has lasted since several years ago, and in 1981, during a meeting in Montpellier, an Interregional Working Group was formed, with Roger Mathieu as a chairman. The Group accepted a common research programme, adopted standardized methods and terminology, and established contacts between Golden Eagle specialists from neighbouring countries—Italy, Spain and Switzerland.

The aim of this year's meeting was to discuss the present situation of the Golden Eagle in Europe and to widen the contacts within European countries. About 200 people arrived in Brunissard. France was represented most numerously, and a fairly large group arrived from Italy. There were also representives from Great Britain, Yugoslavia, Poland, Spain and Switzerland. The audience listened to 26 lectures, 14 of which were from France, 3 from Italy, 2 each from Great Britain and Switzerland, and 1 each from Yugoslavia, Poland and Spain. Additionally, 2 communications were read, having been sent from Austria and Norway. The organizers plan to publish the proceedings in the languages in which the papers were presented during symposium (4 in English, the rest in French). Anyone interested in this publication should contact Samuel Michel, Le Coin, 05390 Molines en Queyras, France.

The symposium was divided into 3 sessions. The first session "Status of Golden Eagle in Europe" lasted the entire first day and was chaired by Roger Mathieu in the morning and by Paolo Fasce in the afternoon. During this session 16 papers were presented. Four of them discussed the status of the eagles in different countries (Britain—Roy Dennis; Italy—Paolo Fasce; Poland—Wojtek Krol; Switzerland—Heinrich Haller), and other concerned smaller administrative or geographical units (e.g. Macedonia—Bratislav Grubac; the Ecrins National Park—Christian Couloumy; Pyrenees—Michel Clout; Sicily—Salvatore Seminara). In most of the papers the authors gave breeding numbersd and density of the eagles in a given area, data on breeding results, nest site selection, food habits, numbers trends and threats for the species.

In the morning of 15 June, there was a session "Biology of the Golden Eagle," chaired by Jean-Francois Terrasse. The first speaker, Roger Mathieu, described "Relationships between age, plumage, behaviour and sexual maturity in the Golden Eagle." In the second lecture Jeff Watson discussed "Land use changes in the Highlands of Scotland and their effects on the Golden Eagle population." Two papers in this session showed the results of investigation on food habits of Golden Eagles—in Spain (Fernandez Leon Carmelo) and in France (Rick Huboux). One lecture concerned breeding biology of the eagle in the Appenines (Bernardo Ragni et al.), and in the last paper Daniel Simeon and Michel Belaud described habitat use by eagles in the sample area of Southern Prealps in France.

In the afternoon Michel Clouet was the chairman. The first speaker, Michel Gillone, a French ethno-ornithologist, gave a lecture "The Golden Eagle in Mexico: a rare and worshipped bird," followed by a session entitled "Management of the Golden Eagle" with 4 papers. Rick Huboux commented on breeding results of Golden Eagles in France in 1964-1984, Jean-Marc Cugnasse described "Management techniques of the Golden Eagle during breeding season," Christian Couloumy talked on "The programme of research on Golden Eagles in the Ecrins National Park, and finally Rick Huboux described "Methods of numbers estimation of Golden Eagles in the Mercantour National Park."

The last point of the programme was the general discussion. It was initiated by Michael Clouet, who pointed out that there is quite a lot of information on eagles breeding in western Europe, while little is known about birds living in the Balcan Peninsula, which feed principally on turtles (Testudo sp.), and not on marmots and lagomorphs like their conspecifics in western Europe. French ornithologists will encourage their colleagues from Yugoslavia and Greece to begin Golden Eagle research by giving them field equipment and methodological advice. As a most important task for the territory of France, Michel Clouet discussed research on the survival and dispersion of young eagles, which can be studied by means of marking birds with wing-tags (this method is already used in Scotland). It turned out however, that for ethical and aesthetical reasons this method has many opponents in France. Among ornithologists present at the symposium, the strongest opposition came from Jean-Francois Terrasse and Michel Gillome. Other research methods were then discussed—telemetry, which is however unpractical in the mountains, and the Argos system (reading transmitter signals by satellite) which is very costly. Little by little the subject of the discussion was changed, and no decision was taken on the matter of wing-tag marking.

The data provided during the symposium show that the situation of the Golden Eagle in Europe is good. Its numbers are estimated to be 3250-3500 pairs (excluding USSR): 450-500 pairs in Scotland; 400 pairs each in Italy, Norway, Sweden and Spain; 200 pairs each in France and Greece; 100-150 pairs each in Bulgaria and Finland; and Albania, Austria, Czechoslovakia, Yugoslavia, Poland, Rumania and West Germany each have < 100 pairs. In some countries an increase of breeding population has been found (e.g. Norway, Scotland, Switzerland) and in others. As a result of recent inventories, many more eagles were discovered than was previously suspected. — **Wojtek Krol, 13, rue Daubenton, 75005 Paris, FRANCE.**

The Grouse and the Goshawk as Prey and Predator. Airing Thursday, 26 February 1987, 8:00 PM EST on PBS (check local listing). A film by Marty Stouffer Productions, Ltd., Aspen, Colorado, as part of the Wild America series, which begins its fifth season in 1987. A half-hour program filmed in the Cascades of Washington and Oregon and hosted by Marty Stouffer.

L'Aquila Reale in Italia: Ecologia e Conservazione. By Paola and Laura Fasce. Lega Italiana Protezione Uccelli, Serie Scientifica, 1984: 66 pp., 15 figs., 14 tables, numerous black and white plates and line drawings, summaries in Italian, English and French, Lira 10,000 excl. of postage. — This work on the Golden Eagle in Italy has chapters entitled, Introduction, Materials and Methods, Biology of the Species, Status of the Species in Italy, Population Dynamics and Problems of Conservation. The first part of the book is on the general biology of the species and the second part contains technical information based on 11 years data collected by thirteen collaborators in the western Italian Alps and northern Apennines. There are estimated to be 183 pairs in the former area (except the Sesia and Ossola valleys) and between 329 and 389 in the latter area. Although I have seen few major works on raptors from Italy this one appears impressive for its thoroughness. — Richard J. Clark.

HOME FREE: Return of the Bald Eagle. A film produced by the Massachusettes Audubon Society, copyright 1984. Length 28 min., color, sound. Available from The New Film Company, Inc., 7 Mystic Street, Suite 118, Arlington, Massachusettes 02174, U.S.A. **Price: $450.00 U.S. on 16 mm, $400.00 U.S. on video; $5.00 U.S. shipping.** Video available in ½" and ¾" VHS. Review copy received in ½" VHS format. Rental rates for free admission showings are $50.00 for one day and $15.00/day for each additional day for 16 mm rental; $35.00 for three days and $10.00/day for each additional for video. Special rates are available for fundraising and other paid admission showings.

The apparent decline of the Bald Eagle in parts of North America has been of concern to conservationists and wildlife biologists for the past several decades, and the species is still listed as either threatened or endangered in the contiguous United States. The film presents a brief story of the Bald Eagle's decline and attempts to reintroduce the species in the area of Quabbin Reservoir in western Massachusettes.

The film begins with an aerial view of Quabbin Reservoir set to music with narration by Jack Swedberg. Besides the Bald Eagle, Swedberg is the main character of the film. Additional narration by Joyce Zinno describes Swedberg's hobby and later profession as a wildlife photographer which eventually leads him to the Bald Eagle. Swedberg was a nature photographer for some 20 years before eventually landing a job as wildlife photographer for the Massachusettes Division of fisheries and wildlife. Swedberg began photographing Bald Eagles during wintering periods, primarily to document their presence in the Quabbin Reservoir area. the first part of the film tells Swedberg's story and contains footage of Swedberg preparing to photograph eagles from a blind.

The film then goes into an encapsulated version of the overall decline of the Bald Eagle, with Swedberg's particular thoughts as to why the birds ceased to breed in western Massachusettes. During this sequence, the film uses black and white still photographs of hunter-killed eagles, of nests, eggs, and young, a close-up shot of a cracked egg in a nest containing one young, and additional narration by Zinno to describe man's impact upon the species. According to the film Swedberg considers loss of habitat to be the primary reason for the extirpation of breeding Bald Eagles in western Massachusettes, but unfortunately this is not expanded upon. Instead, the DDT issue receives a considerable portion of the discussion. The film then shifts back to Swedberg in his blind, and this part of the film ends with some nice footage set to music, although brief, of interractions around a deer carcass between an adult Bald Eagle and a two-year-old immature. The introduction, DDT sequence and photography sequence make up the first 7 min of the film.

The remainder of the film is devoted to documenting the reintroduction of the Bald Eagle into the Quabbin Reservoir area. The initial part of the sequence briefly depicts construction of a hack tower and nest, with narration by Swedberg and Zinno which includes a brief explanation of hacking procedures. Credit for financial support of the project is given to the Massachusettes Audubon Society and the Bank of Boston. The sequence gives a good impression of overall size of a Bald Eagle hack tower, and a good idea of the man-power involved in order to raise such a structure.

Next, Swedberg and members of the U.S. Fish and Wildlife Service are shown preparing for a trip to Canada to take young wild eagles for reintroduction at Quabbin Reservoir. As the flight departs the Quabbin area, there is a brief aerial sequence of the terrain and surrounding regions. Next, the film shifts to a Bald Eagle nest in the Province of Manitoba. The sequence on the ascent of the nest tree is complete with narration of the climber's labored breath, which will bring back memories to anyone who has evrr used tree climbers to scale a tree to a raptor nest. A young eaglet is removed from the nest and lowered to Swedberg waiting at ground level. Some close fottage of young eagles, both in the nest and while being handled on the ground, is shown. The sequence ends with brief aerial footage of a portion of the return flight, and a final landing on Quabbin Reservoir.

After the arrival of the young eagles, the film introduces David Nelson, a Wildlife Biology graduate student at the University of Massachusettes. Nelson is the hack-site attendant, and several aspects of behavior, such as preening, stretching, (mantling), wing exercise, etc., are shown as Nelson narrates from his notes on each individual bird. A portion of the tower enclosure was furnished with one-way glass in order that photographs and observations could be made while the young eagles were growing and developing. Next, there is a brief discussion by Swedberg and Nelson concerning preparations for the release of the young eagles to include a change in their diet. Up to this point, only fish are mentioned as being part of the diet of the Bald Eagle.

The film then shifts to close-up fottage of the young eagles being examined and affixed with patagial markers and radio transmitters. The radio transmitters are shown being attached (sewn) to the central rectrices by an unintroduced individual who narrates part of the sequence. Another individual comments upon the health of the young eagles, including a brief discussion on the physiology of the avian eye. The discussion ends with a comment on the eagle being the "champion visual animal on the earth." The footage of the hack tower and preparation for release of the young eagles lasts approximately 17 min.

The remaining 4 min of the film documents the release of the young eagles from the hack tower set to music. The eagles' enclosure on the hack tower is slowly opened, the young eagles step outside, and finally take flight over Quabbin Reservoir. Following, there is discussion by Swedberg and Nelson concerning the success of the release operation, and a brief shot of Nelson monitoring the eagles' movements with a receiving unit for the radio transmitter. The film ends with a short narration by Swedberg and more aerial footage of Quabbin Reservoir. The credits list numerous other individuals involved with the production of the film, including Media Music and Sound for the musical background.

A brochure which accompanied the film contained several black and white photographs. The brochure also contained some very favorable comments on the film by the Editor of the National

Geographic Society, the President of the National Wildlife Federation, and CBS News. I agree in part with those comments, in that the photography is excellent, the film does hold your attention, and it does tell an environmentally important story. The dedication of Jack Swedberg to returning the Bald Eagle to Quabbin reservoir as a breeding bird cannot be denied after viewing the film. There are portions of the film, however, which require additional comment.

It is unfortunate that the issue of habitat alteration in western Massachusetts was not dealt with more intensively. Instead of the recurring discussion of DDT's impact, educational though it may be, it would have been equally educational and interesting to discuss "before and aftger" documentation of nesting locations within the Bald Eagle's former range in Massachusettes.

At one point in the discussion of the eagle's extirpation in Massachusettes, Swedberg makes the statement that "at the time, no one thought of the idea of hacking eagles." Although an informed viewer would not support such a statement, the uninformed viewer possibly would. Perhaps Swedberg was the first person to think of such an idea in Massachusettes, as was probably the statement's purpose, but the reintroduction of the Bald Eagle into areas elsewhere in the United States has been carried out for several years by numerous organizations and individuals. Nevertheless, the viewer is left with the impression that the film is documenting somewhat of a first. This would be true only on a local level.

Another point of concern is Swedberg's statement that "the eagle is primarily a fish-eater." It has been well documented that the Bald Eagle's diet can be much more varied, and in some wintering areas the diet may consist primarily of mammalian or avian prey, and carrion. Again, such statements might be misleading to an uninformed viewer learning about the Bald Eagle for the first time. General statements concerning the biology of the species should have been carefully edited.

The cost of the film is not warranted from a scientific point of view. However, I would recommend the film on a junior high school or high school level as an introduction to man's efforts to return raptors to former nesting grounds. Although not the quality of the National Audubon Society's 1981 film "Last Stronghold of the Eagles," HOME FREE provides an educational and informative documentary of the effort that is required in attempting to restore the Bald Eagle into its former nesting localities. Although most raptor biologists are well familiar with such undertakings, the general public is not. Education about raptors should be a primary area of concern as we close out the 1980s and move into the 1990s. Films such as HOME FREE are important as a means of educating the public at an early age, an education that hopefully will be remembered later in life. — Jimmie R. Parrish.

DISSERTATION ABSTRACTS

The Feeding Ecology and Breeding Biology of a Cape Vulture Colony in the Southwestern Cape Province

A dissertation submitted to the Faculty of Science,
University of Witwatersrand, Johannesburg,
for the degree of Master of Science.

Johannesburg 1983

Cape Vultures (*Gyps coprotheres*) at Potberg obtain their food from stock farms, within a limited area surrounding the colony. The size of the foraging range was determined by means of a postal survey, and the quantity of food available within it was estimated to exceed the colony's requirements. Data pertaining to daily feeding forays of individuals, monthly foraging patterns and the growth of nestlings indicated no seasonal shortages in the amount of food obtained.

One complete breeding cycle and another two post-fledging dependence periods were observed during 165 days. Results concerning deferred maturity, frequency and success of breeding, a sex-linked difference in behaviour, nestling parasites, behaviour of dependent juveniles, aggressive terminations of the post-fledging period and survival of marked individuals, were obtained. It is suggested that the transition to feeding exclusively on sheep carcasses has not been achieved with equal success by all age groups. — **Robertson, Alistair Stuart, 1983. M.S. thesis, Faculty of Science, University of the Witwatersrand, Johannesburg, South Africa.**

DEDICATION — William Ruttledge wishes to dedicate in retrospect his paper entitled "Captive Breeding of the European Merlin *(Falco columbarius aesalon),* which appeared in Volume 19(2/3), 1985, pp. 68-78 of *Raptor Research,* to the memory of his wife, Dorothy, and in recognition of the very great contribution that she made to the preparation of the manuscript which, sadly, she did not live to see in print.

Mr. Ruttledge takes the opportunity also to give more adequate recognition to the very extensive and invaluable advice given throughout his work by Dr. L. H. Hurrell from his wide experience in captive breeding, including the preparation of MK I and MK II mice (see page 70 of the article).

R A P T O R   R E S E A R C H

A Quarterly Publication of The Raptor Research Foundation, Inc.

Raptor Research (ISSN 0099-9059) welcomes original manuscripts dealing with all aspects of general ecology, natural history, management and conservation of diurnal and nocturnal predatory birds. Send all manuscripts for consideration and books for review to the Editor. Contributions are welcomed from throughout the world, but must be written in English.

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